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VOLUME 20 MAY, 1946 NUMBER 3

COMANCHE ECHINOIDS

C. WYTHE COOKE
Geological Survey, Washington, D. C.

ABSTRACT—The Comanche echinoids of Texas include 38 species and three subspecies, of which four specific names are new. Many other names are synonyms. Of all these species only one ranges throughout the Comanche series and two others occur in two groups; five are restricted to the Trinity group, six to the Fredericksburg group, and 24, together with three subspecies, to the Washita group. The new specific names are *Loriolia rosana*, *L. clarki*, *Anorthopygus texanus*, and *Hemiaster cranium*.

COMANCHE series is the provincial name applied to deposits in the Gulf States, the southern Great Plains States, and southern New Mexico and Arizona that include the upper part of the Lower Cretaceous and the basal beds of the Upper Cretaceous. As echinoids appear to be very rare in the Great Plains States (there are none in the collections studied) this report deals exclusively with the echinoids of Texas and the adjoining parts of Oklahoma, Arkansas, and Mexico. In this region the Comanche series is divided into three stratigraphic groups, the Trinity (lowest), the Fredericksburg, and the Washita, which are separated from one another by local unconformities. The local divisions of these groups are named on a correlation chart by Stephenson and others (1942).

This revision of the Comanche echinoids is based chiefly on collections in the United States National Museum. Through the kindness of Dr. H. B. Stenzel I was permitted to borrow some specimens from the Texas Bureau of Economic Geology; Prof. L. B. Kellum of the University of Michigan loaned me the collection from Mexico reported on by Jones (1938); and Dr. Charles T. Berry of the Johns Hopkins University loaned me types from that institution, which have since been deposited in the United States National Museum.

As most of these collections had already been reported on, it is not surprising that few undescribed species were discovered. Only four species receive new names. One of these, *Anorthopygus texanus*, is a genuine novelty, the first of its genus to be reported from America; another, *Hemiaster cranium*, is a new species of a well-represented genus; the other two, *Loriolia rosana* and *L. clarki*, had homonyms that needed to be replaced. On the other hand, many species had received several synonyms. The net result, therefore, is that the number of valid names is much less than had been supposed. Only 41 names are herein accepted, and of these three are applied to subspecies.

A reason for the multiplicity of synonyms is the disagreement as to the limitation of species. Some writers tend to regard each individual variation as a specific distinction, though even identical twins show some differences and less closely related brothers and sisters may differ markedly from one another. Among the echinoids size and shape

are the most variable features, and the range of variation is proportionately quite as great as in the vertebrates. On the other hand, the oculogenital system and the ambulacral poriferous zones are relatively invariable within the species.

Another reason for the multiplicity of synonyms is the inadequacy of the illustrations of the species. Clark's first paper (1891) was without figures, and Cragin's (1893, 1894) had only a few. Clark's later reports (1893, 1915) were fully illustrated, but many of the drawings were inaccurate, and some of them were wrongly titled.

The names that have been applied to the Comanche echinoids and their assignments herein are listed below in alphabetical order according to species. Those specific names that are regarded as valid are marked with an asterisk. The indented generic names indicate the later combinations to which the preceding specific name has been subjected.

The letters USGS followed by a serial number refer to collections listed in the Mesozoic locality register maintained by the Geological Survey at the United States, National Museum. Catalogue numbers of the National Museum are indicated by USNM.

List of Synonyms

adkinsi, Holectypus, Smiser 1936 = *Holectypus* (*Coenholectypus*) *planatus* Roemer 1852.
aguilerae, Epiaster, Böse 1910 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
Macraster (Böse) Adkins 1928.
**angustatus, Echinobrissus*, Clark 1915 = *Clypeopygus angustatus* (Clark).
Porobrissus, (Clark) Lambert 1916.
Nucleopygus (*Porobrissus*), (Clark) Lambert & Thiéry 1921.
Clypeopygus, (Clark) Lambert & Thiéry 1921.
**argutus, Leptarbacia*, Clark 1915 = *Diademopsis* (*Leptarbacia*) *arguta* (Clark) 1915.
Diademopsis Clark Cooke, n. comb.
böhmi, Enallaster, de Loriol 1904 = *?Enallaster texanus* (Roemer) 1849.
bösei, Epiaster, Lambert 1924 = *?Hemiaster whitei* (Clark) 1891.
bösei, Tetragramma, Jones 1938 = *?Tetragramma malbosii* (Agassiz) 1847.
bravoensis, Enallaster, Böse 1910 = *?Enallaster texanus* (Roemer) 1849.
Heteraster, (Böse) Lambert 1927.
**budaensis, Goniopygus*, Whitney 1916 = *Goniopygus budaensis* Whitney 1916.
bulloides, Pyrina, Cragin 1893 = *?Globator parryi* (Hall) 1857.
Pseudopyrina?, (Cragin) Adkins 1928.
**calvini, Hemiaster*, Clark 1893 = *Hemiaster calvini* Clark, 1893.
Epiaster, (Clark) Lambert 1927.
**castilloi, Holectypus*, Cotteau 1890 = *Holectypus* (*Coenholectypus*) *castilloi* Cotteau 1890.
cenomanensis, Holectypus, Guéranger 1859 = *Holectypus* (*Coenholectypus*) *planatus* Roemer 1852.
**charltoni, Hemipedina*, Cragin 1894 = *Orthopsis charltoni* (Cragin) 1894.
charltoni, Holectypus, Cragin 1893 = *Holectypus* (*Coenholectypus*) *castilloi* Cotteau 1890.
**clarki, Loriola*, Cooke, n. name = *Loriolia clarki* Cooke, n. name.
clarki, Pyrina, Böse 1910 = *Globator parryi* (Hall) 1857.
Pseudopyrina (Böse) Adkins 1928.
**comanchei, Hemiaster*, Clark 1915 = *Hemiaster comanchei* Clark 1915.
Hemiaster (*Mecaster*), Clark. Lambert & Thiéry
Palhemiaster, (Clark) Smiser 1936.
comanchesi, Holaster, Marcou 1858 = *Holaster laevis* (Brongniart) 1822.
**completus, Holaster*, Cragin 1893 = *Pseudananchys completa* (Cragin) 1893.
Pseudananchys, (Cragin) Lambert & Thiéry 1924.
**cranium, Hemiaster*, Cooke, n. sp. = *Hemiaster cranium* Cooke, n. sp.
cuevasensis, Epiaster, de Loriol 1904 = *?Hemiaster comanchei* Clark 1915.
denisonensis, Macraster, Smiser 1936 = *Hemiaster elegans washitae* (Lambert) 1920.
**electus, Epiaster*, Cragin 1893 = *Hemiaster? electus* (Cragin) 1893.
Hemiaster?, (Cragin) Cooke, n. comb.
**elegans, Hemiaster*, Shumard 1853 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
Toxaster, (Shumard) Gabb 1859.
Epiaster, (Shumard) Clark 1891.
Macraster, (Shumard) Lambert 1927.
**elegans Hypodiadema*, Clark 1915 = *Pseudocidaris elegans* (Clark) 1915.
Pseudocidaris, (Clark) Lambert 1927.
engerrandi, Holectypus, Lambert 1927 = *Holectypus* (*Coenholectypus*) *planatus* Roemer.
engerrandi, Pedinopsis, Ikins 1940 = *Pedinopsis yarboroughi* Ikins 1940.

hemiasterinus, Epiaster, Cragin 1893 = *?Hemiaster calvini* Clark 1893.
**hemigranosus, Cidaris*, Shumard 1860 = *Cidaris hemigranosus* Shumard 1860.
Leiocidaris, (Shumard) Clark 1891.
inaudita, Pyrina, Böse 1910 = *Globator parryi* (Hall) 1857.
Pseudopyrina, (Böse) Smiser 1936.
inflatus, Enallaster, Cragin 1893 = *?Enallaster texanus* (Roemer) 1849.
Heteraster, (Roemer) Lambert 1927.
inflatus, Pliotoxaster, Smiser 1936 = *Hemiaster elegans washitae* (Lambert) 1920.
kansasense, Salenia, Twenhofel 1924 = *?Salenia mexicana* Schlüter 1887.
kentensis, Macraster, Adkins 1930 = *Hemiaster elegans subobesus* (Adkins) 1920.
**laevis, Spatangus*, Brongniart 1822 = *Holaster laevis* (Brongniart) 1822.
Holaster, (Brongniart) Agassiz 1836.
leanderensis, Salenia, Ikins 1940 = *?Salenia volana* Whitney 1916.
limitis, Holectypus, Böse 1910 = *Holectypus* (*Coenholectypus*) *transpecosensis* Cragin 1893.
lineatus, Micropsis, Clark 1915 = *Diademopsis* (*Leptarbacia*) *arguta* (Clark) 1915.
Echinopsis, (Clark) Lambert 1927.
**longisulcus, Enallaster*, Adkins & Winton 1920 = *Enallaster longisulcus* Adkins & Winton 1920.
Washitaster, (Adkins & Winton) Lambert 1927.
**malbosii, Diadema*, Agassiz 1847 = *Tetragramma malbosii* (Agassiz) 1847.
Diplopodia, (Agassiz) Desor 1858.
Pseudodiadema, (Agassiz) Cotteau 1863.
Tetragramma, (Agassiz) Lambert & Thiéry 1910.
**mexicana, Salenia*, Schlüter 1887 = *Salenia mexicana* Schlüter 1887.
**mexicanum, Phymosoma*, Böse 1910 = *Phymosoma mexicanum* Böse 1910.
mexicanus, Enallaster, Cotteau 1890 = *?Enallaster texanus* (Roemer)1849.
nanus, Holaster, Cragin 1893 = *Holaster laevis* (Brongniart) 1822.
nodopyga, Macraster, Lambert 1920 = *Hemiaster elegans wenoensis* (Adkins) 1920.
nodulosus, Spatangus, Goldfuss 1829 = *Holaster laevis* (Brongniart) 1822.
obesus, Macraster, Adkins 1930 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
obliquatus, Enallaster, Clark 1893 = *Enallaster texanus* (Roemer) 1849.
Heteraster (Clark) Lambert 1920.
**occidentalis, Orthopsis*, Cragin 1893 = *Orthopsis occidentalis* Cragin, 1893.
ornatum, Heterodiadema, Clark 1915 [not (Goldfuss) 1826] = *Loriolia clarki* Cooke, n. name.
Trochotiara, Lambert 1916.
Loriolia, Lambert 1927.
ovatus, Macraster, Smiser 1936 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
**parryi, Pyrina*, Hall 1857 = *Globator parryi* (Hall) 1857.
Pseudopyrina, (Hall) Lambert 1927.
Globator, (Hall) Cooke, n. comb.
**planatus, Holectypus*, Roemer 1852 = *Holectypus* (*Coenholectypus*) *planatus* Roemer 1852.
planulata, Orthopsis, Clark 1915 = *Orthopsis charltoni* (Cragin) 1894.
praenuntius, Epiaster, Cragin 1893 = *Hemiaster whitei* (Clark) 1891.
pseudoelegans, Macraster, Adkins 1930 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
riovistae, Hemiaster, Adkins 1920 = *Enallaster texanus* (Roemer) 1849.
Washitaster, (Adkins) Lambert 1927.
roemeri, Pseudodiadema, Clark 1891 [not Desor 1858] = *Loriolia rosana* Cooke, n. sp.
**rosana, Loriolia*, Cooke, n. sp. = *Loriolia rosana* Cooke, n. sp.
**rotula, Cottaldia*, Clark 1915 = *Cottaldia rotula* Clark 1915.
Pseudodiadema, (Clark) Smiser 1936.
saleniaformis, Goniopygus, Ikins & Clabaugh 1940 = *Goniopygus zittelli* Clark 1891.
**scotti, Goniophorus*, Lambert 1926 = *Goniophorus scotti* Lambert 1926.
sellardsi, Codiopsis, Ikins = *?Codiopsis texana* Whitney 1916.
simplex, Holaster, Shumard 1853 = *Holaster laevis* (Brongniart) 1822.
solitariensis, Macraster, Smiser 1936 = *Hemiaster comanchei* Clark 1915.
stenzeli, Salenia, Ikins 1940 = *?Salenia volana* Whitney 1916.
stocktonensis, Goniopygus, Smiser 1936 = *?Goniopygus budaensis* Whitney 1916.
**streeruwitzi, Diplopodia*, Cragin 1893 = *Tetragramma streeruwitzi* (Cragin) 1893.
Tetragramma, (Cragin) Lambert 1927.
**subobesus, Epiaster*, Adkins 1920 = *Hemiaster elegans subobesus* (Adkins) 1920.
Macraster (Adkins) Lambert 1927.
supernus, Holaster, Cragin 1893 = *Pseudananchys completa* (Cragin) 1893.
Stenonia, (Cragin) Adkins 1918.
Pseudananchys, (Cragin) Lambert & Thiéry 1924.
**symmetrica, Dumblea*, Cragin 1893 = *Pedinopsis symmetrica* (Cragin) 1893.
Pedinopsis, (Cragin) Clark 1915.
Micropedina (Cragin) Adkins 1928.

taffi, Diplopodia, Cragin 1893 = *Tetragramma malbosii* (Agassiz) 1847.
**texana, Codiopsis*, Whitney 1916 = *Codiopsis texana* Whitney 1916.
**texana, Salenia*, Credner 1875 = *Salenia texana* Credner 1875.
**texanum, Diadema*, Roemer 1849 = *Phymosoma texanum* (Roemer) 1849.
Cyphosoma, (Roemer) Roemer 1852.
Phymosoma, (Roemer) Desor 1858.
Pseudodiadema, (Roemer) Clark 1891 [part].
Diplopodia, (Roemer) Clark 1893 [part].
texanum, Diadema, Roemer 1852 [not Roemer 1849] = *Loriolia rosana* Cooke, n. sp.
Pseudodiadema, Desor 1858.
Heterodiadema (*Loriolia*), Lambert & Thiéry 1910.
Trochotiara, Lambert & Thiéry 1910.
Loriolia, Lambert 1927.
**texanus, Anorthopygus*, Cooke, n. sp. = *Anorthopygus texanus* Cooke, n. sp.
texanus, Cidaris, Clark 1891 = *Cidaris hemigranosus* Shumard 1860.
texanus, Goniopygus, Ikins & Clabaugh 1940 = *Goniopygus zitteli* Clark 1891.
texanus, Macraster, Roemer 1888 = *Hemiaster* (*Macraster*) *elegans* Shumard 1853.
**texanus, Toxaster*, Roemer 1849 = *Enallaster texanus* (Roemer) 1849.
Enallaster, (Roemer) d'Orbigny 1853.
Heteraster, (Roemer) Shumard 1860.
**transpecosensis, Holectypus*, Cragin 1893 = *Holectypus* (*Coenholectypus*) *transpecosensis* Cragin 1893.
traski, Enallaster, Whitney 1916 = *?Enallaster texanus* (Roemer) 1849.
**volana, Salenia*, Whitney 1916 = *Salenia volana* Whitney 1916.
volanum, Cyphosoma, Cragin 1893 = *Phymosoma texanum* (Roemer) 1849.
Phymosoma, (Cragin) Lambert 1927.
**washitae, Macraster*, Lambert 1920 = *Hemiaster elegans washitae* (Lambert) 1920.
Hemiaster, (Lambert) Cooke, n. comb.
wenoensis, Enallaster, Adkins 1920 = *Enallaster texanus* (Roemer) 1849.
Heteraster, (Adkins) Lambert 1927.
**wenoensis, Epiaster*, Adkins 1920 = *Hemiaster elegans wenoensis* (Adkins) 1920.
Macraster, (Adkins) Lambert 1927.
Hemiaster, (Adkins) Cooke, n. comb.
**whitei, Epiaster*, Clark 1891 = *Hemiaster whitei* (Clark) 1891.
Hemiaster, (Clark) Clark 1915.
Pliotoxaster, (Clark) Lambert 1920.
whitneyi, Goniophorus, Ikins 1940 = *?Goniophorus scotti* Lambert 1926.
**whitneyi, Pseudodiadema*, Ikins 1940 = *Loriolia whitneyi* (Ikins) 1940.
Loriolia, (Ikins) Cooke, n. comb.
whitneyi, Pyrina, Ikins 1940 = *Globator parryi* (Hall) 1857.
**yarboroughi, Pedinopsis*, Ikins 1940 = *Pedinopsis yarboroughi* Ikins 1940.
**zitteli, Goniopygus*, Clark 1891 = *Goniopygus zitteli* Clark 1891.

STRATIGRAPHIC RANGE

In the determination of the stratigraphic ranges of the species I have been hampered by the lack of personal acquaintance with the region. It has been necessary to rely chiefly on the information given on the labels, many of which are very old and possibly incorrect. My colleagues on the Geological Survey, Lloyd W. Stephenson, John B. Reeside, Jr., Ralph W. Imlay, and A. Nelson Sayre, have given helpful suggestions from their greater knowledge of local conditions.

In the following list the initials T, F, or W preceding the name of the species signifies that it occurs in the Trinity, the Fredericksburg, or the Washita group. Further information about the occurrence follows the synonymy or the description of each species.

STRATIGRAPHIC RANGE OF COMANCHE ECHINOIDS

	Cidaridae	Page
W	*Cidaris hemigranosus* Shumard	199
T	*Pseudocidaris elegans* (Clark)	200
	Saleniidae	
F	*Goniopygus zitteli* Clark	201
W	*Goniopygus budaensis* Whitney	201
W	*Goniophorus scotti* Lambert	202
T	*Salenia texana* Credner	203
F	*Salenia mexicana* Schlüter	204
W	*Salenia volana* Whitney	204
	Phymosomatidae	
T	*Loriolia rosana* Cooke, n. sp.	205
F	*Loriolia whitneyi* (Ikins)	206
W	*Loriolia clarki* Cooke, n. name	206
F	*Tetragramma malbosii* (Agassiz)	207
W	*Tetragramma streeruwitzi* (Cragin)	208
FW	*Phymosoma texanum* (Roemer)	209
W	*Phymosoma mexicanum* Böse	211
	Echinidae	
F	*Pedinopsis yarboroughi* Ikins	212
W	*Pedinopsis symmetrica* (Cragin)	211

	Echinidae (*cont.*)	Page
W	*Diademopsis* (*Leptarbacia*) *arguta* Clark	213
W	*Orthopsis occidentalis* Cragin	214
W	*Orthopsis charltoni* (Cragin)	214
W	*Cottaldia rotula* Clark	215
W	*Codiopsis texana* Whitney	216
	Holectypidae	
TF	*Holectypus* (*Coenholectypus*) *planatus* Roemer	217
W	*Holectypus* (*Coenholectypus*) *castilloi* Cotteau	218
W	*Holectypus* (*Coenholectypus*) *transpecosensis* Cragin	218
	Pygasteridae	
W	*Anorthopygus texanus* Cooke, n. sp.	219
	Echinoneidae	
W	*Globator parryi* (Hall)	221
	Cassidulidae	
W	*Clypeopygus angustatus* (Clark)	222
	Hemiasteridae	
T	*Hemiaster comanchei* Clark	223
T	*Hemiaster? electus* (Cragin)	224
F	*Hemiaster whitei* (Clark)	224
W	*Hemiaster calvini* Clark	225
W	*Hemiaster cranium* Cooke, n. sp.	226
W	*Hemiaster* (*Macraster*) *elegans* Shumard	227
W	*Hemiaster elegans wenoensis* (Adkins)	228
W	*Hemiaster elegans subobesus* (Adkins)	229
W	*Hemiaster elegans washitae* (Lambert)	229
TFW	*Enallaster texanus* (Roemer)	231
W	*Enallaster longisulcus* Adkins and Winton	232
	Echinocorythidae	
W	*Pseudananchys completa* (Cragin)	233
W	*Holaster laevis* (Brongniart)	234

Of the 38 species and three subspecies recognized as valid, five species appear to be restricted to the Trinity group, six to the Fredericksburg group, and 24 species and three subspecies to the Washita group. One species, *Enallaster texanus*, ranges throughout the Comanche series; *Phymosoma texanum* occurs in both the Fredericksburg group and the Washita group; and *Holectypus planatus* is common to the Trinity and the Fredericksburg groups. All the species in the Trinity are reported from the Glen Rose limestone; there seem to be several echinoid-bearing horizons in the Fredericksburg and the Washita groups, but the apparent restriction of certain species to a single horizon may be the result of incomplete collection or ecologic variation rather than the short duration of the species.

Most of the genera represented are well known in Europe, but few direct comparisons with foreign specimens have been possible. *Holectypus cenomanensis* Guéranger 1859, rare in the Cenomanian of France, is regarded as a synonym of *H. planatus* Roemer 1852, common in the Trinity and Fredericksburg groups. *Tetragramma malbosii* (Agassiz), said to be representative of the Aptian in Europe (Lambert, 1927, p. 266), occurs in the Fredericksburg group. *Holaster laevis* Brongniart 1822, from the Upper Greensand of England, seems to be identical with the common *H. simplex* Shumard 1853, from the Washita group. Lambert (1927, pp. 273, 274) lists several other species that he regards as identical with or closely related to European species.

CLASSIFICATION

The classic division into regular and irregular echinoids, based on the location of the periproct within or outside of the apical system, which was followed for convenience in my two papers on the Cenozoic echinoids (Cooke, 1941, 1942), is not applicable to the Lower Cretaceous echinoids because three families represented include features elsewhere peculiar to each division. In the Phymosomatidae, which resemble regular echinoids in all other respects, the periproct appears to be emerging from the apical system though still adjacent to it. In the Holectypidae, which have the five genital plates, the central, notched peristome, and the circular or subpentagonal shape of the regular echinoids, the periproct is completely outside of the apical system and below the ambitus. The location of the periproct is a notably variable feature among echinoid genera. The genus *Anorthopygus* (Pygasteridae) combines the central, notched peristome with the four genital plates and the external periproct of the irregular echinoids.

The number and arrangement of the genital plates seem to be of much importance in the taxonomy of echinoids. In the accompanying dichotomous key to the genera, the primary division is therefore made on the number of genital plates, whether five, which division includes all the regular echinoids, or four, which includes most of the irregular echinoids. The secondary divisions are based on features of the ambulacral areas or on the location of the peristome.

KEY TO THE GENERA OF COMANCHE ECHINOIDS

1. Having five genital plates; symmetry radial; peristome circular, central, generally notched; periproct commonly (not invariably) within the apical system.
  2. Ambulacral areas narrow, tubercles smaller than those in the interambulacral areas; apical plates thick, raised.
    3. Tubercles perforate; apical system without accessory plates ..... Cidaridae.
      4. Tubercles uniformly graduated in size ..... *Cidaris.*
      4. Tubercles on under side larger than those above ..... *Pseudocidaris.*
    3. Tubercles imperforate ..... Saleniidae.
      4. Apical system generally without a suranal plate; genital pores at outer ends of plates; periproct central, within apical system ..... *Goniopygus*
      4. Apical system having a suranal plate; genital pores not at outer ends of plates; periproct eccentric though within the apical system.
        5. Apical system sharply pentagonal, crossed by straight ridges; periproct behind the suranal plate ..... *Goniophorus.*
        5. Apical system not sharply pentagonal; periproct to the right of the suranal plate. *Salenia.*
  2. Ambulacral areas wide, tubercles not smaller than those in interambulacral areas.
    3. Apical system large, loose, commonly not preserved, scar pentagonal, with one point longer than the others; test depressed ..... Phymosomatidae.
      4. Poriferous zone uniserial throughout, broken into diagonal groups of three near the peristome; tubercles perforate ..... *Loriolia.*
      4. Poriferous zones biserial on top, uniserial or in arcs underneath.
        5. Tubercles perforate; poriferous zones uniserial underneath ..... *Tetragramma.*
        5. Tubercles imperforate; poriferous zones in arcs underneath ..... *Phymosoma.*
    3. Apical system small, attached, commonly preserved.
      4. Periproct within the apical system ..... Echinidae.
        5. Poriferous zones biserial or staggered.
          6. Poriferous zones biserial throughout; ambulacral plates very much shorter than wide; tubercles arranged in transverse rows ..... *Pedinopsis.*
          6. Poriferous zones staggered, not biserial throughout; ambulacral plates not much shorter than wide; tubercles arranged in vertical rows ..... *Diademopsis* (*Leptarbacia*).
        5. Poriferous zones uniserial.
          6. Tubercles perforate, perforations sometimes obliterated.
            7. Tubercles of unequal sizes, plainly perforate; test generally depressed .... *Orthopsis.*
            7. Tubercles of equal rank, small, arranged in horizontal rows; perforations very minute, commonly obliterated; test generally globular ..... *Cottaldia.*
          6. Tubercles imperforate; large tubercles confined to bottom, arranged in a star-shaped pattern ..... *Codiopsis.*
      4. Periproct outside the apical system, basal .... Holectypidae. *Holectypus* (*Coenholectypus*).
1. Having only four genital plates; periproct outside the apical system.
  2. Peristome central; poriferous zones continuous, not petaloid, all alike; periproct terminal or above the ambitus, flush.
    3. Periproct symmetrical, higher than wide, not oblique; test spheroidal; peristome flush, generally oblique ..... Echinoneidae. *Globator.*
    3. Periproct asymmetrical, oblique; test equilateral; peristome sunken, notched, not oblique. ..... Pygasteridae. *Anorthopygus.*
  2. Peristome anterior, not central, symmetrical; poriferous zones petaloid or subpetaloid, not continuous.
    3. Periproct opening into a deep sulcus on top; poriferous zones petaloid, all alike ..... Cassidulidae. *Clypeopygus.*
    3. Periproct flush.
      4. Apical system compact, anterior paired oculars not in contact, poriferous zones petaloid, anterior zones generally unlike the paired petals; petals commonly sunken .... Hemiasteridae.
        5. Pore pairs of anterior area alike, generally chevron-shaped; peripetalous fasciole generally present ..... *Hemiaster.*
        5. Pore pairs of anterior area unlike; without fascioles ..... *Enallaster.*
      4. Apical system not compact, anterior paired oculars in contact ..... Echinocorythidae.
        5. Anterior poriferous zones like the others; not sulcate in front nor truncate behind .... *Pseudananchys.*
        5. Anterior poriferous zones unlike the others; sulcate in front and truncate behind .... *Holaster.*

SYSTEMATIC DESCRIPTIONS

Family CIDARIDAE

Genus CIDARIS Leske, 1778

Cidaris papillata LESKE, 1778, Klein's Naturalis dispositio Echinodermatum, p. 125, = *Echinus cidaris* Linné.
Cidarites (part) LAMARCK, 1816, Histoire naturelle des animaux sans vertèbres, t. 3, p. 52.
Cidarites (*Phyllacanthus*) BRANDT, 1835, Prodomus descriptionis animalium, fasc. 1, p. 68.
Cidaris, A. AGASSIZ, 1872, Harvard College Mus. Comp. Zoology Mem., vol. 3, p. 252.
Cidaris (*Eucidaris*) POMEL, 1883, Classification méthodique et genera des échinides, p. 109.
Cidaris, H. L. CLARK, 1907, Harvard College Mus. Comp. Zoology Bull., vol. 51, p. 183.
Cidaris, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 2, p. 141.
Eucidaris, MORTENSEN, 1928, A monograph of the Echinoidea; I, Cidaroidea, p. 286.
Cidaris, GRANT AND HERTLEIN, 1938, California Univ. (Los Angeles) Pub. Math. and Phys. Sci., vol. 2, p. 4.
Cidaris, COOKE, 1941, Jour. Paleontology, vol. 15, no. 1, p. 5.

Genotype, *Echinus cidaris* Linné, by absolute tautonomy. This is a species living in the Indo-Pacific region, probably the one identified by A. Agassiz (1872, p. 385, pl. 1g, fig. 1) as *Cidarites metularia* Lamarck. If so, *Eucidaris* Pomel as interpreted by Mortensen becomes an absolute junior synonym of *Cidaris*.

Leske did not define *Cidaris* but included in it a great variety of echinoids representing many genera as now divided. His *Cidaris papillata* has been split into several species. *Dorocidaris abyssicola* A. Agassiz (1869, p. 253) was later identified as the typical *C. papillata*, and the monotypic *Dorocidaris* was reduced to a subgenus (A. Agassiz, 1872, p. 254). Other parts of *Cidaris papillata* became *Cidarites tribuloides* Lamarck and *Cidarites imperialis* Lamarck, which Brandt (1835, p. 68) named as representative of sections A and B, respectively, of his new subgenus *Phyllacanthus*. *C. imperialis*, according to Lambert and Thiéry (1910, p. 153), is the genotype of *Leiocidaris* Desor, 1856. More recent writers, particularly Mortensen (1928), have split the natural genus *Cidaris* into innumerable so-called genera, basing many of them on trivial differences that appear to be at most subgeneric or even merely specific variations. The Cidaridae should be restudied by some one who has access to both Recent and fossil specimens and who has a better sense of proportion in the evaluation of morphological features.

CIDARIS HEMIGRANOSUS Shumard

Cidaris hemigranosus SHUMARD, 1860, St. Louis Acad. Sci. Trans., vol. 1, p. 609.
Cidaris hemigranosus, WHITE, 1883, U. S. Geol. and Geog. Survey Ter., 12th Ann. Rept. (for 1878), pt. 1, p. 38, pl. 18, figs. 2a–b.
Leocidaris hemigranosus, CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 75.
?Cidaris texanus CLARK, 1891, *idem*, p. 75.
?Cidaris texanus, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 36, pl. 7, figs. 1a–e.
Leiocidaris hemigranosus, CLARK, 1893, *idem*, p. 38, pl. 7, figs. 2a–d; pl. 8, figs. 1a–b; pl. 9, figs. 1a–c.
Leiocidaris hemigranosus, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 160, pl. 46, fig. 4.
Leiocidaris hemigranosus, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 48, pl. 10, figs. 1a–g; pl. 11, figs. 1a–b.
?Cidaris texanus, CLARK, 1915, *idem*, p. 45, pl. 9, figs. 2a–f.
Leiocidaris hemigranosus, ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 49, pl. 9, fig. 6; pl. 20, fig. 3.
Leiocidaris hemigranosus, WINTON, 1925, *idem*, Bull. 2544, p. 57, pl. 13, fig. 2.
Leiocidaris hemigranosus, LAMBERT, 1927, Soc. géol. France Bull., t. 26, p. 265.
?Dorocidaris texanus, LAMBERT, 1927, *idem*, p. 265.
Leiocidaris hemigranosus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 271, pl. 14, fig. 2.
?Dorocidaris texanus, ADKINS, *idem*. p. 271.

Occurrence.—TEXAS: Upper part of the bluffs of Red River, Lamar County (*fide* Shumard); Cook County (USNM 21768, cast, O. A. Ellithorp, collector, original figured by Clark, 1893, pl. 9; 1915, pl. 10); Travis County (USNM 19094); Bexar County (USNM 8381, type of *C. texanus*). Other localities are cited by Adkins (1928).

OKLAHOMA: Ten miles above the mouth of Kiamesha Creek (*fide* Shumard; i.e., near Sawyer, Choctaw County, *fide* Adkins, 1928).

Geologic horizon.—Washita group; Denton clay and possibly higher formations (*fide* Adkins, 1928).

Type.—Unknown, possibly in the St. Louis Academy of Sciences.

Remarks.—*Cidaris hemigranosus* is large and globular. The specimen figured by Clark (1893, pl. 9; 1915, pl. 10) under that specific name measures about 65 mm. high by 85 mm. wide. The tubercles above the ambitus are much larger than those below.

The holotype of *C. texanus* is a fragment preserving only the lower half. Its tubercles are somewhat smaller than the corresponding ones on the larger specimen, and its granulation is less coarse. These differences are probably functions of its size.

Genus PSEUDOCIDARIS Étallon, 1862

Hemicidaris (part) AGASSIZ, 1840, Soc. helvétique sci. nat. Nouv. Mém., t. 4, p. 42.
Hemicidaris, sec. c, WRIGHT, 1857, British fossil Echinodermata of the Oolitic formations, vol. 1, p. 69.
Pseudocidaris ÉTALLON, 1862, Soc. émulation Département Doubs Mém., ser. 3, t. 6, p. 221.
Hemicidaris (part), COTTEAU, 1863, Paléontologie française, Terrain crétacé, t. 7, p. 379.
Pseudocidaris, DESOR AND DE LORIOL, 1869, Échinologie helvétique, pt. 1, p. 88.
Pseudocidaris, COTTEAU, 1880, Paléontologie française, Terrain jurassique, t. 10, pt. 2, p. 13.
Pseudocidaris, POMEL, 1883, Classification méthodique et genera des échinides, p. 95.
Pseudocidaris, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 167.

Genotype, *Hemicidaris thurmanni* Agassiz (1840b, p. 50, pl. 19, figs. 1–3), from the Jurassic (Portlandian) of France, designated by Lambert and Thiéry (1910). It is further described and figured by Cotteau (1880, p. 32, pl. 269, figs. 6–15; pl. 270, figs. 1–9).

Pseudocidaris thurmanni has narrow, crooked ambulacral areas that expand a little on the base, where they are decorated with two short rows of small crenulated, perforated tubercles. The ambulacral pores are in uniserial pairs except near the peristome, where they become disarranged. The interambulacral plates are about as high as wide, and each has a large central tubercle surrounded by granules. The apical plates are plainly dicyclic. The peristome is large and very weakly notched.

Pseudocidaris has fewer coronal plates than *Hemicidaris* Agassiz (1840, genotype *Cidarites crenularis* Lamarck), and its tubercles are much farther apart. Its peristome is much more weakly notched. The spines, also, are said to differ.

PSEUDOCIDARIS ELEGANS (Clark)
Plate 32, figures 8–10

Hypodiadema elegans CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 52, pl. 14, figs. 2a–b.
Pseudocidaris elegans, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Pseudocidaris elegans, ADKINS, 1928, Texas Univ. Bull. 2838, p. 273.

Occurrence.—ARKANSAS: Junction of Muddy and Clear Forks of Little Missouri River, Pike County, 3 miles west of Murfreesboro (USGS 2214, J. A. Taff).

Geologic horizon.—Trinity group; Dierks limestone.

Type.—USNM 31196.

Remarks.—This species is known only from the type, a well-preserved specimen.

Family SALENIIDAE
Genus GONIOPYGUS Agassiz, 1838

Goniopygus AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 19.
?Acropeltis AGASSIZ, 1840, Catalogus systematicus ectyporum Echinodermatum, p. 19.
?Acropeltis, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 36.
Goniopygus, AGASSIZ AND DESOR, 1847, *idem*, p. 40.
?Acropletis, DESOR, 1858, Synopsis des échinides fossiles, p. 85.
Goniopygus, DESOR, 1858, *idem*, p. 93.
Goniopygus, COTTEAU, 1865, Paléontologie française, Terrain crétacé, t. 7, p. 717.
?Acropeltis, COTTEAU, 1883, *idem*, Terrain jurassique, t. 10, p. 561.
Goniopygus, COTTEAU, 1883, *idem*, p. 568.
?Acropeltis, POMEL, 1883, Classification méthodique et genera des échinides, p. 89.
Goniopygus, POMEL, 1883, *idem*, p. 89.
Cyphopygus, POMEL, 1883, *idem*, p. 89.
Goniopygus, VALETTE, 1906, Soc. des sci. hist. et nat. de l'Yonne Bull., t. 59, p. 280.
?Polygoniopygus VALETTE, 1906, *idem*, p. 281. (Genotype, *Goniopygus pilleti* Cotteau, 1883.)
?Acropeltis, LAMBERT AND THIÉRY, 1914, Nomenclature raisonnée des échinides, fasc. 4, p. 267.
Goniopygus, LAMBERT AND THIÉRY, 1914, *idem*, p. 267.

Genotype, *Echinus menardi* Desmarest (in Defrance, 1825), from the lower Senonian of France, designated by Valette (1906, p. 280). This species has been figured by Agassiz (1838, p. 22, pl. 3, figs. 29–36) and by Cotteau (1865, p. 734, pls. 1179, 1180). Its coronal plates are very much like those of *Salenia*, having imperforate tubercles, but there are three pairs of pores instead of two to each ambulacral tubercle. The apical system is dicyclic. The genital plates together form a five-pointed star, and the genital pores are at the outer points. Three of the genital plates are represented as having a tubercle on the inner edge adjacent to the periproct.

The number and location of the tubercles on the genital plates have been regarded as generic features, but in all probability they are variable, even within the species. *Acropeltis aequituberculata* Agassiz (Cotteau, 1883, p. 562, pls. 412, 413), the genotype of *Acropeltis*, seems to differ from *Goniopygus* chiefly in having one large tubercle near the center of each genital plate instead of at the edge. The genotype of *Cyphopygus* Pomel (*Goniopygus major* Agassiz, 1838) has a marginal tubercle on each genital plate instead of on only three.

That a suranal plate is sometimes preserved on individuals of *Goniopygus* is indicated by the presence of such a plate on *Goniopygus saleniaformis* Ikins and Clabaugh, which is here regarded as probably an individual variant of *Goniopygus zitteli* Clark. In *Goniopygus bolaensis* Jones (1938, p. 132, pl. 13, figs. 5, 6, 8) from the Aurora formation of Coahuila, the periproct is slightly eccentric, but there seems to be no suranal plate.

Valette (1906, p. 280) proposed to restrict *Goniopygus* to species having only three pairs of pores for each ambulacral tubercle and erected *Polygoniopygus* to receive species having more than three pairs. He chose *Goniopygus pilleti* Cotteau (1883, p. 570, pl. 413, figs. 7–12), a Jurassic species, as genotype and included in the genus three Cretaceous species. This distinction appears to be of very doubtful value, for *Goniopygus zitteli* has both three and four pairs of pores to the tubercle on the same individual, the difference seeming to be merely a matter of size.

GONIOPYGUS ZITTELI Clark
Plate 31, figure 24

Goniopygus zitteli CLARK, 1891, Johns Hopkins Univ. Circ. vol. 10, no. 87, p. 76.
Goniopygus zitteli, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 53, pl. 18, figs. 2a–d; pl. 19, figs. 1a–e.
Goniopygus zitteli, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 52, pl. 14, figs. 3a–c; pl. 15, figs. 1a–h.
Goniopygus zitteli, Lambert, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 268.
Goniopygus zitteli, ADKINS, 1928, Texas Univ. Bull. 2838, p. 280.
Goniopygus saleniaformis, IKINS AND CLABAUGH, 1940, Bull. Am. Paleontology, vol. 26, no. 96, p. 268, pl. 40, figs. 3a–d.
Goniopygus texanus, IKINS AND CLABAUGH, 1940, *idem*, p. 269, pl. 40, figs. 4a–d.

Occurrence.—TEXAS: Round Rock, Williamson County (type); Noland Creek at crossing of Central Avenue, 4500 feet east of courthouse, Belton, Bell County USGS 11851, T. W. Stanton).

Geologic horizon.—Fredericksburg group: Edwards limestone.

Type.—USNM 12234a.

Remarks.—Clark's figures are based on two individuals, one of which, showing the apical system but not the base, is selected as the type. The other (USNM 12234b) shows the base but has lost the apical system. There are nine other individuals from the same locality bearing the number 12234. Clark's (1915, pl. 15, fig. 1d) figure of the ambulacral area is defective in that it represents each plate as containing four pairs of pores, whereas the upper plates contain only three pairs.

Goniopygus zitteli is very similar to *G. major* Agassiz (1838, p. 25, pl. 4, figs. 17–22) as figured by Cotteau (1865, p. 740, pls. 1181, 1182, figs. 1–4) and may prove to be the same species. *G. major* is reported as rare in the Cenomanian of France.

Goniopygus saleniaformis and *G. texanus* are based on small, probably immature individuals from the Edwards limestone 10 miles southwest of Kerrville, Kerr County, Texas. Both of these supposed species are reported to have fewer apical tubercles than the type of *G. zitteli*, and *G. saleniaformis* has a suranal plate. Nevertheless, it appears likely that both are merely variants of *G. zitteli*.

GONIOPYGUS BUDAENSIS Whitney

Goniopygus budaensis WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 90, pl. 16, figs. 1–8.
Goniopygus budaensis, ADKINS, 1928, Texas Univ. Bull. 2838, p. 280.
Goniopygus budaensis, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 459.
?Goniopygus stocktonensis, SMISER, 1936, *idem*, p. 459, pl. 62, figs. 7, 16.

Occurrence.—TEXAS: Austin (type, *fide* Whitney). Smiser reports it from Brewster County. *G. stocktonensis* came from Seven Mile Mesa, about 7 miles northeast of Fort Stockton, Pecos County.

Geologic horizon.—Washita group: Buda limestone (type), Georgetown limestone (Smiser).

Type.—University of Texas, Austin.

Remarks.—This species, which I have not seen, apparently was described from juveniles. The periproct is somewhat eccentric.

Genus GONIOPHORUS Agassiz, 1838

Goniophorus AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 30.
Goniophorus, AGASSIZ, 1840, Catalogus systematicus ectyporum echinodermatum, p. 19.
Goniophorus, AGASSIZ AND DESOR, 1847, Catalogue raisonné des échinodermes, p. 39.
Goniophorus, DESOR, 1858, Synopsis des échinides fossiles, p. 146.
Goniophorus, COTTEAU, 1861, Paléontologie française, Terrain crétacé, t. 7, p. 125.
Goniophorus, WRIGHT, 1872, British fossil Echinodermata from the Cretaceous formations, vol. 1, pt. 5, p. 165.
Gonosalenia QUENSTEDT, 1875, Petrefactekunde Deutschlands, Band 3, p. 36.
Goniophorus, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 209.

Genotype, *Goniophorus lunulatus* Agassiz, from the Cenomanian of France, determined by Cotteau, who threw the names of the only other species described by Agassiz into the synonymy. This species is figured by Agassiz, Desor, and by Cotteau (1861, p. 126, pl. 1029, figs. 8–19).

Goniophorus differs from *Salenia* in the shape and ornamentation of its apical system, which is sharply pentagonal and decorated by straight ridges connecting the pores; in the location of its periproct, which is behind the suranal plate, not to the right of it as in *Salenia;* and in the presence of a deep pit containing a pair of accessory pores behind several of the ambulacral tubercles near the ambitus. The ridges on the apical plates are a distinctive feature that permits the ready recognition of the genus when they are preserved. Most juveniles retain them, but they appear to be lost rather early in life, for mature individuals usually show only traces of apical ridges.

GONIOPHORUS SCOTTI Lambert
Plate 31, figures 8, 9

Goniophorus scotti LAMBERT in SCOTT, 1926, Études strat. et paléont. sur les terrains crétacés du Texas, p. 185.
Gonophiorus scotti, LAMBERT, 1927, Soc. géol. France Bul., sér. 4, t. 26, p. 268, text fig. 1. (Typographical error.)
Goniophorus scotti, ADKINS, 1928, Texas Univ. Bull. 2838, p. 278, pl. 12, fig. 8.
?Goniophorus whitneyi IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 69, pl. 5, figs. 4a–c.

Occurrence.—TEXAS: Cut on military road one-third mile north of Texas Christian University, Fort Worth (type, *fide* Adkins); 1½ miles north of Texas Christian University (USNM 103877, E. T. Dumble); military road one-half mile north of Texas Christian University (USGS 11747, T. W. Stanton); 3 miles northwest of Texas Christian University along small stream south of Santa Fe Railroad underpass (USGS 18399, Ralph Imlay); Tarrant County 0.5 mile south of road 0.8 mile east of junction of Denton highway (377) and the Saginaw road (USGS 19700, Renfro coll.).

Geologic horizon.—Washita group: The type came from the Duck Creek limestone; the specimens listed are from the Duck Creek, Fort Worth, and Weno limestones. The type of *Goniophorus whitneyi* came from the Grayson shale (Del Rio clay) in Brewster County, Texas.

Type.—Probably in the collection of M. Jules Lambert.

Remarks.—The type and most of the specimens examined are juveniles less than 5 mm. in diameter. These show very plainly the straight ridges connecting the genital and ocular pores, but the ridges are worn off from most older individuals. The specimen from USGS 18399, which is 15 mm. in diameter, barely shows traces of the ridges, and there are only vestiges of ridges on the one from USGS 19700, which measures 18 mm. in diameter.

Genus SALENIA Gray, 1835

Salenia GRAY, 1835, Zool. Soc. London Proc., vol. 3, p. 58.
Cidarella DES MOULINS, 1837, Soc. linn. Bordeaux Actes, t. 9, p. 53.
Salenia, AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 6.
Salenia, AGASSIZ, 1840, Catalogues systematicus ectyporum echinodermatum, p. 19.
Salenia, AGASSIZ AND DESOR, 1847, Catalogue raissoné des échinodermes, p. 37.
Salenia, DESOR, 1856, Synopsis des échinides fossiles, fasc. 3, p. 148.
Salenia, COTTEAU, 1861, Paléontologie française, Terrain crétacé, t. 7, p. 130.
Salenia, WRIGHT, 1872, British fossil Echinodermata from the Cretaceous formations, vol. 1, pt. 5, p. 169.
Salenia, POMEL, 1883, Classification méthodique et genera des échinides, p. 93.
Salenia, COTTEAU, 1892, Paléontologie française, Terrain tertiaire, t. 2, p. 479.
Salenia, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 210.

Salenia, COOKE, 1941, Jour. Paleontology, vol. 15, no. 1, p. 7.

Genotype, *Cidarites scutiger* Münster (in Goldfuss, 1826, pl. 49, figs. 4a–b), by monotypy, from the Cenomanian of Germany. This species has been figured also by Cotteau (1861, p. 154, pls. 1036, 1037).

Several species of *Salenia* are reported by Cotteau (1892) from the Eocene of France, Spain, and India, and there is one in the early Eocene Vincentown sand of New Jersey[1] (Cooke, 1941, p. 7). Alexander Agassiz (1872, p. 261, pl. 3, figs. 8–14) refers the Recent species *Salenocidaris varispina* A. Agassiz (1869) to *Salenia*, but his figures suggest that it is closer to *Peltastes*.

Three species of *Salenia* are here recognized in the Comanche series—*S. texana* in the Trinity group, *S. mexicana* in the Fredericksburg group, and *S. volana* in the Washita group. Of these *S. texana* is the most abundantly represented in the collections of the National Museum, but the state of preservation is such that the range of variation cannot satisfactorily be determined. The most obvious differences between the three species are the shape and ornamentation of the apical plates. The plates of *S. texana* and *S. volana* are entire or weakly lobed, but those of *S. texana* are flat, while those of *S. volana* are radially ribbed or fluted. The plates of *S. mexicana* are strongly lobed. These differences appear to be constant, though there is some variation in the extent of lobation, and some of the plates have been corroded.

Several supposed species are based on the number of coronal plates. This feature should be used with caution, for the number varies within the species according to the age and size of the individual.

SALENIA TEXANA Credner
Plate 31, figure 3

Cidaris diatretum Morton. GIEBEL, 1853, Naturwiss. Ver. in Halle Jahresber. 1852, p. 374, pl. 7, fig. 2.

Salenia texana CREDNER, 1875, Zeitschr. gesammten Naturwiss., neue Folge, Band 12 (46), p. 111, pl. 5, figs. 1–6.

[1] Comparison of the holotypes of *Salenia tumidula* Clark and *S. bellula* Clark, both from the Vincentown sand, indicates that they represent only one species.

Occurrence.—TEXAS: Cibolo, 8 miles from Comanche Spring (type, *fide* Giebel); Cibolo River 2½ miles west of Bulverde road crossing, Bexar County (USGS 10200, O. B. Hopkins); 2 miles north of Guadalupe River at Crane's Mill and 150 feet above it (USGS 1866, Stanton, Whitney, and Tyson); 3.4 miles north of Guadalupe River at Crane's Mill and 150 feet above it (USGS 11867, Stanton, Whitney, and Tyson); road to New Braunfels 2½ miles east of Crane's Mill (USGS 11869, Stanton, Whitney, and Tyson); 1½ miles south of Pleasant Valley Crossing, Blanco River, road to Fisher's store, Comal County (USGS 18390, Ralph Imlay).

Geologic horizon.—Trinity group: Glen Rose limestone.

Type.—Probably at the University of Halle, Germany.

Remarks.—*Salenia texana* seems to have been generally misinterpreted. The type apparently came from the Glen Rose limestone, and specimens from that horizon agree well with Credner's excellent drawings. Cragin (1893, p. 163) provisionally referred to *S. texana* specimens of *S. mexicana* Schlüter from the Fredericksburg group in Bandera County that he said agree well with the description of *S. mexicana*, and therefore he regarded *S. mexicana* as probably a synonym of *S. texana*. Clark (1893, 1915) figured as *S. texana* a *Salenia* from the Washita group that is probably the species later (1916) named *Salenia volana* Whitney.

Salenia texana differs from *S. mexicana* and *S. volana* in the shape and ornamentation of its apical plates. The apical plates of *S. texana* are flat and smooth except for a minute shagreenlike vermiculation. The sutures are commonly inconspicuous except at the perforations, which tend to be longitudinal, though some are transverse. The plates are rarely divided into lobes. The apical plates of *S. mexicana* are strongly lobed and resemble cogwheels. The apical plates of *S. volana* are faintly radially fluted.

Salenia texana closely resembles *S. prestensis* Desor from the Aptian of Switzerland as figured by Pictet and Renevier (1858, p. 159, pl. 2, figs. 6a–c) and may prove to be a synonym of it.

SALENIA MEXICANA Schlüter
Plate 31, figures 1, 2

Salenia mexicana SCHLÜTER, 1887, Naturh. Ver. preuss. Rheinlande u. Westfalens Sitzungsber., Jahrg. 44, p. 41.
Salenia prestensis Desor. COTTEAU, 1890, Soc. géol. France Bull., sér. 3, t. 18, p. 294.
Salenia texana Credner. CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 163.
Salenia mexicana, BÖSE, 1910, Inst. geol. México Bol. 25, p. 152, pl. 32, figs. 4–19.
Salenia mexicana, ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 49, pl. 9, figs. 14–17.
?Salenia kansasense TWENHOFEL, 1924, Kansas Geol. Survey Bull. 9, p. 52, pl. 7, fig. 7.
Salenia mexicana, WINTON, 1925, Texas Univ. Bull. 2544, p. 50, pl. 12, figs. 6–8.
Salenia prestensis texana Credner. LAMBERT, 1926, Soc. géol. France Bull., t. 26, p. 267.
Selania texana Credner (part). ADKINS, 1928, Texas Univ. Bull. 2838, p. 277.
Salenia mexicana, ADKINS, 1928, *idem*, p. 278.
Salenia prestensis Desor. ADKINS, 1928, *idem*, p. 277.
Salenia prestensis Desor. SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 457.
?Salenia scotti, IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 66, pl. 5, figs. 1a–c.

Occurrence.—MEXICO: La Encantada, near the gold placers of Guadalupe, Chihuahua (type).

TEXAS: Bluff on Brazos River about 4 miles northwest of Whitney (USGS 11842, T. W. Stanton); 2 miles northwest of Talley Rancho, Madera Mountain quadrangle, Pecos County, about 20 miles south of Fort Stockton (USGS 13882, N. H. Darton); about 6 miles south of Quitman Canyon, Sierra Blanca quadrangle (USGS 1895, T. W. Stanton); Rockwood Park Road at the White Settlement Road, 2½ miles northwest of down-town Fort Worth (USGS 19681, Renfro collection); near Fort Worth (USNM 31129); 8.3 miles southeast of Glen Rose (USGS 19679, Renfro collection).

Geologic horizon.—Fredericksburg group.

Remarks.—Full-grown individuals of *Salenia mexicana* are smaller than *S. texana*, their ambulacral plates are straighter, and the two rows of ambulacral tubercles are farther apart. Their apical plates, though variable, resemble cog wheels and are usually radially ribbed. Besides the species listed in the synonymy, *Salenia sergipensis* White (1887), *S. similis* White (1887), and *S. similis lastroensis* Maury (1936), all from the middle Albian of Brazil, should be compared with *Salenia mexicana*.

Salenia mexicana has radially lobed apical plates like those of *S. triboleti* Desor (1856, p. 151; Pictet and Renevier, 1858, p. 160, pl. 22, figs. 7a–c, 8), which is commonly placed in the synonymy of *S. prestensis* Desor.

SALENIA VOLANA Whitney
Plate 31, figure 4

Salenia texana Credner. CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 40, pl. 10.
Salenia texana Credner. CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 49, pl. 12, figs. 1a–i; pl. 14, figs. 1a–c.
Salenia volana WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 88, pl. 15, figs. 1–9.
Salenia volana, LAMBERT, 1926, Soc. géol. France Bull., t. 26, p. 267.
Salenia volana, ADKINS, 1928, Texas Univ. Bull. 2838, p. 278.
?Salenia leanderensis IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 64, pl. 4, figs. 4a–c.
?Salenia stenzeli IKINS, 1940, *idem*, p. 67, pl. 5, figs. 2a–c.

Occurrsnce.—TEXAS: Shoal Creek at Austin (*fide* Whitney); Manchaca (*fide* Whitney); Bexar County (USNM 8329, specimens figured as *S. texana* by Clark); Round Rock station, Williamson County (USNM 12234).

Geologic horizon.—Washita group: The type came from the lower part of the Buda limestone.

Type.—University of Texas, Austin.

Figured specimen.—USNM 8329c, Bexar County, Texas.

Remarks.—Though the type of *Salenia volana* has not been available for direct comparison, Whitney's excellent figures give a good basis for the identification of the specimens in the United States National Museum. *S. volana*, from the Washita group, is more similar to *S. texana*, from the Trinity group, than to *S. mexicana*, from the Fredericksburg group. The apical plates of *S. volana* are radially ribbed, which distinguishes it from *S. texana*, and their lack of conspicuous lobation distinguishes it from *S. mexicana*, whose plates are strongly lobate.

Family PHYMOSOMATIDAE
Genus LORIOLIA Neumayr, 1881

Loriolia NEUMAYR, 1881, Deutsche geol. Gesell. Zeitschr., Band 33, p. 570.
Tiarella (*Tiaromma*) POMEL, 1883, Classification méthodique et genera des échinides, p. 105.

Trochotiara LAMBERT, 1901, in KILLIAM AND PETITCLERC, Contr. étude bajocien nord Franche-Conté, t. 3, pp. 223, 236 (*fide* Neave).
Heterodiadema (*Loriolia*), LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 180.
Trochotiara, LAMBERT AND THIÉRY, 1910, *idem*, p. 181.

Genotype, *Pseudodiadema foucardi* Cotteau (1851) from the middle Neocomian of the Yonne, France, by monotypy. Neumayr's description of *Loriolia* was based on figures by Cotteau (1863, p. 419, pl. 1097, figs. 1–5) of a specimen, presumably the type, which Cotteau then identified as a variety of *Pseudodiadema bourgueti* (Agassiz). These figures represent a small (diameter 18 mm.) individual retaining all the paired oculars and the posterior paired genital plates in a monocyclic arrangement partly enclosing an elongated periproct. The posterior oculars are elongated and lead to a shallow emargination in the coronal plates of the posterior interambulacral area. This emargination may indicate the location of the posterior genital plates, as in *Glyphocyphus radiatus* (Hoeninghaus) (Cotteau, 1864, p. 535, pl. 1127, fig. 7). Neumayr suggested that part of the apical scar may have been occupied by accessory plates, as in the Saleniidae, but that seems most unlikely; and he also suggested relationship with *Hyboclypeus*, which seems still more improbable. The poriferous zones are uniserial throughout but are crowded near the peristome. The tubercles are perforate.

Loriolia may be a subgenus of *Heterodiadema* Cotteau, 1862, as indicated by Lambert and Thiéry, but the emargination of *H. libyca* (Desor) (Cotteau, 1864, p. 522, pl. 1124), genotype of *Heterodiadema*, is very much deeper, extending halfway to the ambitus, suggesting that its periproct is outside of the oculogenital ring.

LORIOLIA ROSANA Cooke, n. sp.
Plate 31, figures 15–17

Diadema texanum ROEMER, 1852, Kreidebildungen von Texas, p. 83, pl. 10, figs. 5a–c. Not *Diadema texanum* Roemer, 1849, = *Phymosoma texanum* (Roemer).
Pseudodiadema texanum, DESOR, 1858, Synopsis des échinides fossiles, p. 72.
Pseudodiadema roemeri CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 75. Not *Pseudodiadema roemeri* Desor, 1858.
Pseudodiadema texanum, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 47, pl. 13, figs. 2a–b; pl. 14, figs. 1a–g.
Pseudodiadema texanum, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 161.
Pseudodiadema texanum, HILL, 1901, U. S. Geol. Survey Ann. Rept. 21, pl. 27, figs. 3a–b (after Clark, 1893).
Heterodiadema (*Loriolia*) *texana*, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 181.
Trochotiara texana, LAMBERT AND THIÉRY, 1910, *idem*, p. 183.
Pseudodiadema texanum, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 55, pl. 18, figs. 1a–i (after Clark, 1893).
Loriolia texana, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Loriolia texana, ADKINS, 1928, Texas Univ. Bull. 2838, p. 273, pl. 1, figs. 6, 7.

Test rather small, nearly circular, gently convex above, concave below. Apical system always wanting; scar generally pentagonal, with one point extended into the posterior interambulacral area, apparently indicating that the oculogenital ring was elongated, causing the scar to be longer than wide. Ambulacral areas about half as wide as interambulacral areas; pores uniserial, in a straight line except near the peristome, where they are arranged in slightly diagonal groups of three. Posterior interambulacral area slightly depressed near the apical scar. Two rows of nearly equal perforated, crenulated primary tubercles in each area, one on each plate, surrounded by closely crowded large miliary granules. Peristome circular, less than half the diameter, deeply notched. Diameter of holotype, 15 mm.; altitude, 6 mm.; diameter of peristome, 6 mm. Diameter of a larger individual, 22 mm.

Occurrence.—TEXAS: Elbow on south side of Barton Creek between Oatmanville and Bee Caves, Travis County (specimen figured by Clark, USGS 66, R. T. Hill and T. W. Vaughan); Bee Caves road 2 miles southeast of Turkey Foot, about 15 miles west of Austin (USGS 10883, L. W. Stephenson); 11 or 12 miles southwest of Fredericksburg on road to Kerrville (USGS 1633); Turtle Creek, Kerr County (type, USGS 10483, C. Habecker); hill south of camp no. 6, Hays County (USGS 58, T. W. Vaughan); cut on Kerre Creek road about one-fourth mile south of hill 112 on the Leon Springs Military Reservation, Bexar County (USGS 8736, Alexander Deussem); west side of

Shaner's ranch, 3 miles west of Leon Springs (USGS 63, R. T. Hill); Sanchez Creek about 6 miles southwest of Weatherford, Parker County (USGS 18573, Ralph Imlay); east bank of east fork of Nueces River 2 miles north of Round Mountain, in northeast corner of Brackett quadrangle (USGS 13628, T. W. Stanton and N. H. Darton).

Geologic horizon.—Trinity group: Glen Rose limestone.

Type.—USNM 103878, Turtle Creek, Kerr County, Texas.

Remarks.—This species appears to differ from *Loriolia whitneyi* (Ikins) in the shape of its apical scar, which is usually elongated into the posterior interambulacral area, whereas that of *L. whitneyi* is nearly equilateral, and in the width of its peristome, which appears to be proportionately smaller.

LORIOLIA WHITNEYI (Ikins)

Polydiadema texanum (Roemer). LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Polydiadema texanum (Roemer). ADKINS, 1928, Texas Univ. Bull. 2838, p. 275.
Pseudodiadema whitneyi IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 72, pl. 6, figs. 1a–c.

Occurrence.—TEXAS: Borrow pit on west side of road 1 mile north of Leander (type, *fide* Ikins).

Geologic horizon.—Fredericksburg group: upper part of the Walnut clay (*fide* Ikins).

Type.—University of Texas.

Remarks.—*Loriolia whitneyi*, the type of which I have not seen, appears to have a proportionately larger peristome than *L. rosana*. It may differ also in the shape and size of its apical scar, which is said to be smooth and without posterior groove and which seems to be larger.

LORIOLIA CLARKI Cooke, n. name
Plate 31, figures 13, 14

Heterodiadema ornatum CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 56, pl. 18, figs. 2a–f. Not *Loriolia ornata* (Goldfuss), 1826.
Trochotiara ornata (Clark) LAMBERT, 1916, Rev. crit. zoologie, t. 20, no. 4, p. 169.
Heterodiadema ornatum (Clark) LAMBERT AND THIÉRY, 1925, Nomenclature raisonnée des échinides, fasc. 8, p. 563.
Loriolia ornata (Clark) LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Loriolia ornata (Clark) ADKINS, 1928, Texas Univ. Bull. 2838, p. 273.

Test about half as high as wide, outline circular, slightly concave around the peristome, somewhat depressed behind the periproct. Apical scar a large five-pointed star, with the posterior projection longer than the others and rounded. Ambulacral areas slightly flexuous; pores uniserial, very straight except near the peristome, where they are arranged in diagonal groups of three; half as wide as the interambulacral areas. Each area containing two rows of primary perforated, faintly crenulated tubercles; interspaces closely covered with small tubercles and granules. Peristome circular, deeply notched, one-third the total width of the test. Periproct possibly partly outside of the apical system. Diameter, 23 mm.; altitude, 11.5 mm.; diameter of peristome, 8 mm.; length of apical scar, 10 mm.

Occurrence.—TEXAS: Fort Worth.

Geologic horizon.—Washita group.

Type.—USNM 103,702, deposited by Johns Hopkins University.

Remarks.—This species is represented by a single specimen. As left by Clark, it was partly covered by hard brownish limestone, which covered the peristome and obscured the apical scar. The specimen is almost certainly congeneric with those figured by Cotteau (1864, p. 480, pl. 1115) under the name *Pseudodiadema ornatum*, which he identified as *Cidarites ornata* Goldfuss. Clark's name is therefore a homonym. The figures of *Loriola ornata* (Goldfuss) have proportionately narrower and more weakly notched peristomes but in other respects are very similar to the specimen from Texas.

Genus TETRAGRAMMA Agassiz, 1838

Tetragramma AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 4.
Tetragramma, AGASSIZ, 1840, Allg. schweiz. Gesell. gesammten Naturwiss. n. Denkschr., Band 4, p. 24.
Tetragramma, AGASSIZ, 1840, Catalogus systematicus ectyporum Echinodermatum, pp. 9, 18.
Diadema (*Tetragramma*), AGASSIZ AND DESOR, 1847, Catalogue raisonné des échinodermes, p. 46.
Diplopodia M'COY, 1848, Annals and Mag. Nat. History, ser. 2, vol. 2, p. 412. Genotype, *Diadema subangulara* Agassiz (not Goldfuss) = *Pseudodiadema aroviente* Desor, from Jurassic of Switzerland, designated by Pomel, 1883.
Pseudodiadema (part) DESOR, 1855, Synopsis des échinides fossiles, p. 75.
Diplopodia, DESOR, 1855, *idem*, p. 75.
Pseudodiadema (part), COTTEAU, 1863, Paléon-

tologie française, Terrain crétacé, t. 7, p. 407.
Pseudodiadema (part), COTTEAU, 1881, *idem*, Terrain jurassique, t. 10, p. 226.
Diplopodia, POMEL, 1883, Classification méthodique et genera des échinides, p. 104.
Tetragramma, POMEL, 1883, *idem*, p. 104.
Tetragramma (*Hexagramma*), POMEL, 1883, *idem*, p. 104. Genotype, *Tetragramma planissimum* Agassiz, by monotypy.
Pseudoplopodia VALETTE, 1906, Soc. des sci. hist. et nat. de l'Yonne, t. 59, p. 294. Genotype, *Tetragramma planissimum* Agassiz, here designated.
Diplopodia, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 185.
Diplopodia (*Tetragramma*), LAMBERT AND THIÉRY, 1910, *idem*, p. 187.
Diplopodia (*Tetragramma*), IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 56.

Genotype, *Cidarites variolaris* Brongniart (1822), from the Cenomanian of France, by original designation. This species has been figured by Cotteau (1864, p. 488, pls. 1117–1120). It is characterized by a double row of pore pairs on the upper part changing to a single row, which becomes crowded around the peristome, and by perforated tubercles arranged in parallel rows, which increase in number with age. The apical system is known only by its scar, which is subpentagonal with slightly protruding corners.

Tetragramma is easily distinguished from *Phymosoma* by its perforated tubercles, though the two genera are superficially very similar.

Lambert and Thiéry and Ikins have independently called *Tetragramma* a subgenus of *Diplopodia* in violation of Article 28 of the International Code of Zoological Nomenclature.

TETRAGRAMMA MALBOSII (Agassiz)

Diadema malbosii AGASSIZ, 1847, in AGASSIZ AND DESOR, Catalogue raisonné des échinodermes, p. 46.
Diplopodia malbosii, DESOR, 1858, Synopsis des échinides fossiles, p. 78, pl. 12, figs. 12–14.
Pseudodiadema malbosi, COTTEAU, 1863, Paléontologie française, Terrain crétacé, t. 7, p. 448, pls. 1106, 1107.
Pseudodiadema malbosi, WRIGHT, 1868, British fossil Echinodermata from the Cretaceous formations, vol. 1, p. 91, pl. 20, figs. 1a–f.
Diplopodia malbosi, COTTEAU, 1890, Soc. géol. France Bull., sér. 3, t. 18, p. 294.
Diplopodia texanum (Roemer) (part). CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 48, pl. 15, figs. 1a–f; pl. 16, figs. 1a–d.
Diplopodia taffi CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 148, pl. 46, fig. 3.
Diplopodia taffi DE LORIOL, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, p. 56, pl. 7, figs. 14–14b.
Tetragramma malbosi, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 188.
?Pseudodiadema (*Diplopodia*) *texanum* (Roemer). BÖSE, 1910, Inst. geol. México Bol. 25, p. 157, pl. 34, figs. 4–8; pl. 36, figs. 1, 2.
Diplopodia taffi, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 58, pl. 20, figs. 2a–e.
Cyphosoma texanum (Roemer) (part). CLARK, 1915, *idem*, p. 60, pl. 21, figs. 1a–e (not figs. 1f–g).
Tetragramma malbosi, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Tetragramma taffi, ADKINS, 1928, Texas Univ. Bull. 2838, p. 274.
?Tetragramma bösei JONES, 1938, Geol. Soc. America Bull., vol. 49, p. 130, pl. 12, figs. 6, 7.

Occurrence.—EUROPE: France and England.

TEXAS: North San Gabriel River 3 miles above Georgetown, Williamson County (type of *Diplopodia taffi* Cragin); University Mesa, 15 miles northeast of Fort Stockton, Pecos County (USGS 14221, T. W. Stanton and W. P. Popenoe); Alamita Canyon, southeast of Shafter, Presidio County (USGS 14299, N. H. Darton); roadside one-half mile west of Santa Fe quarry, 3 miles west of Belton, Bell County (USGS 11850, T. W. Stanton); Chalk Mountain, 12 miles southwest of Glen Rose, Somervell County (USGS 1545, Frank Burns); 8.3 miles southeast of Glen Rose, creek east of Glen Rose—Walnut Springs road (Highway 144), Bosque County (USGS 19679, Renfro collection); 13.8 miles northwest of the county courthouse, Fort Worth (USGS 19683, Renfro collection).

Geologic horizon.—Fredericksburg group. According to Lambert (1927) *Tetragramma malbosii* is characteristic of the Aptian in Europe.

Type.—The type, T. 63, has been figured by Desor (1858) and Cotteau (1863). The type of *Diplopodia taffi* is probably at the University of Texas; that of *Tetragramma bösei* is University of Michigan 1663.

Remarks.—*Diplopodia taffi* is identified as *Tetragramma malbosii* partly on the authority of Lambert (1927) and partly on the comparison of specimens from Texas with two from Ramonde near Marbonne, France (USNM 28853). These French specimens do not show clearly the apical scar nor the

peristome, for they are partly covered by hard matrix and their identification is open to question. The ornamentation is very similar to that of the Texan specimens. The type of *Tetragramma bösei* is too thickly covered by hard limestone to be certainly identifiable without better-preserved topotypes.

TETRAGRAMMA STREERUWITZI (Cragin)
Plate 31, figure 23

Diplopodia streeruwitzi CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 147, pl. 24, fig. 11; pl. 25, figs. 8–10.
Pseudodiadema (*Diplopodia*) cfr. *variolare* Brongniart. BÖSE, 1910, Inst. geol. México Bol. 25, p. 155, pl. 33, figs. 1–6; pl. 34, figs. 1, 2.
Diplopodia streeruwitzi, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 58, pl. 20, figs. 3a–c.
Tetragramma streeruwitzi, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Tetragramma streeruwitzi, ADKINS, Texas Univ. Bull. 2838, p. 274.
Tetragramma streeruwitzi, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 456.

Occurrence.—TEXAS: Sierra Blanca Mountains (type); gap between North and South Sierra Blanca Peaks, Hudspeth County (USGS 1813, 1914, T. W. Stanton); 1 mile south-southeast of station at Kent, Culberson County (USGS 1931, T. W. Stanton); one-quarter mile southwest of station at Kent (USGS 1932, T. W. Stanton); near water tank 8 miles southwest of Kent (USGS 1939, T. W. Stanton); south side of Rio Grande near El Paso between the railway bridge and the Initial Monument (E. A. Mearns).

MEXICO: Cerro Muleros above the Initial Monument (*fide* Böse).

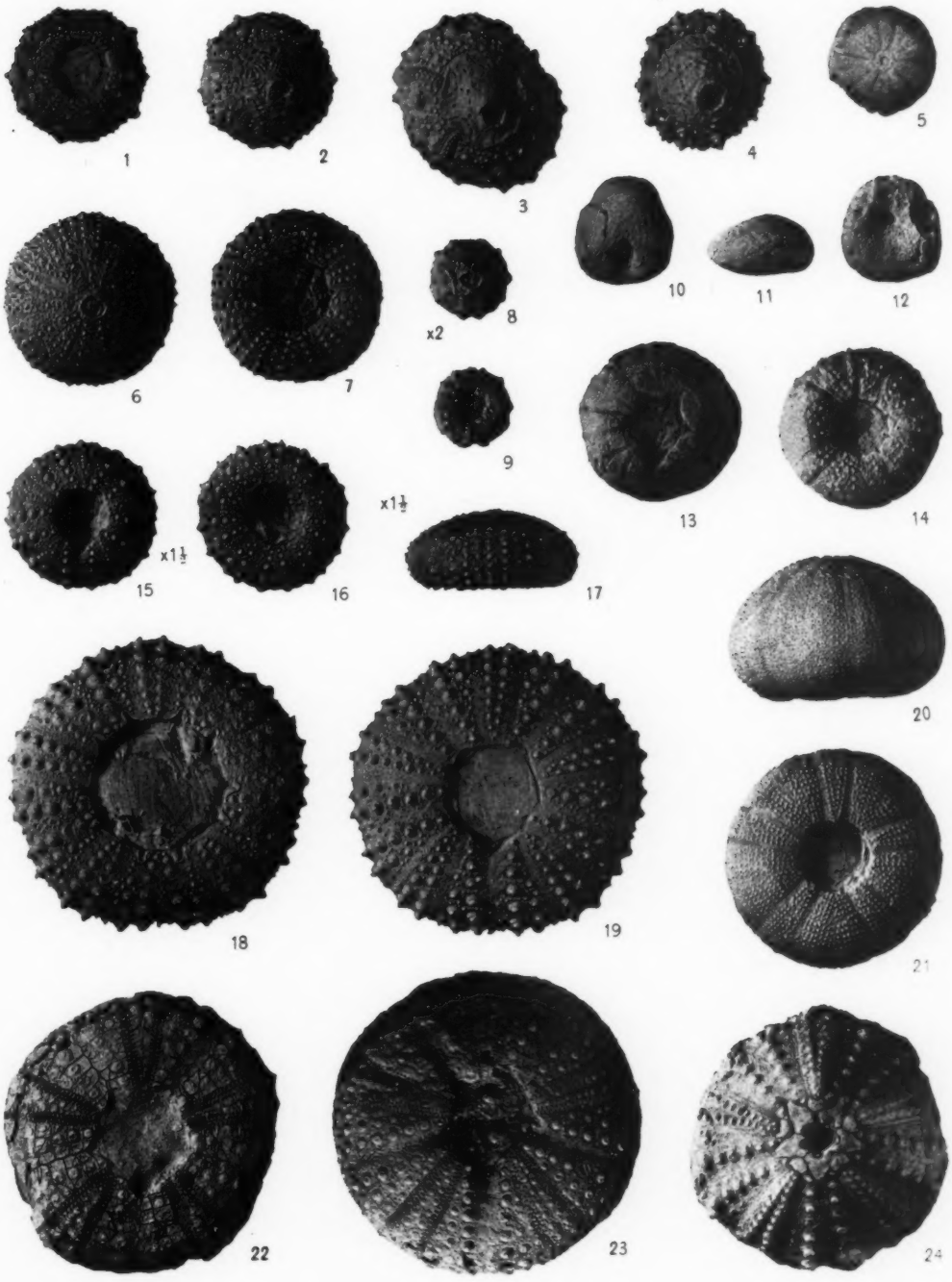
Geologic horizon.—Washita group.

Type.—Texas Bureau of Economic Geology, Austin. On temporary deposit at U. S. National Museum. Figured by Clark.

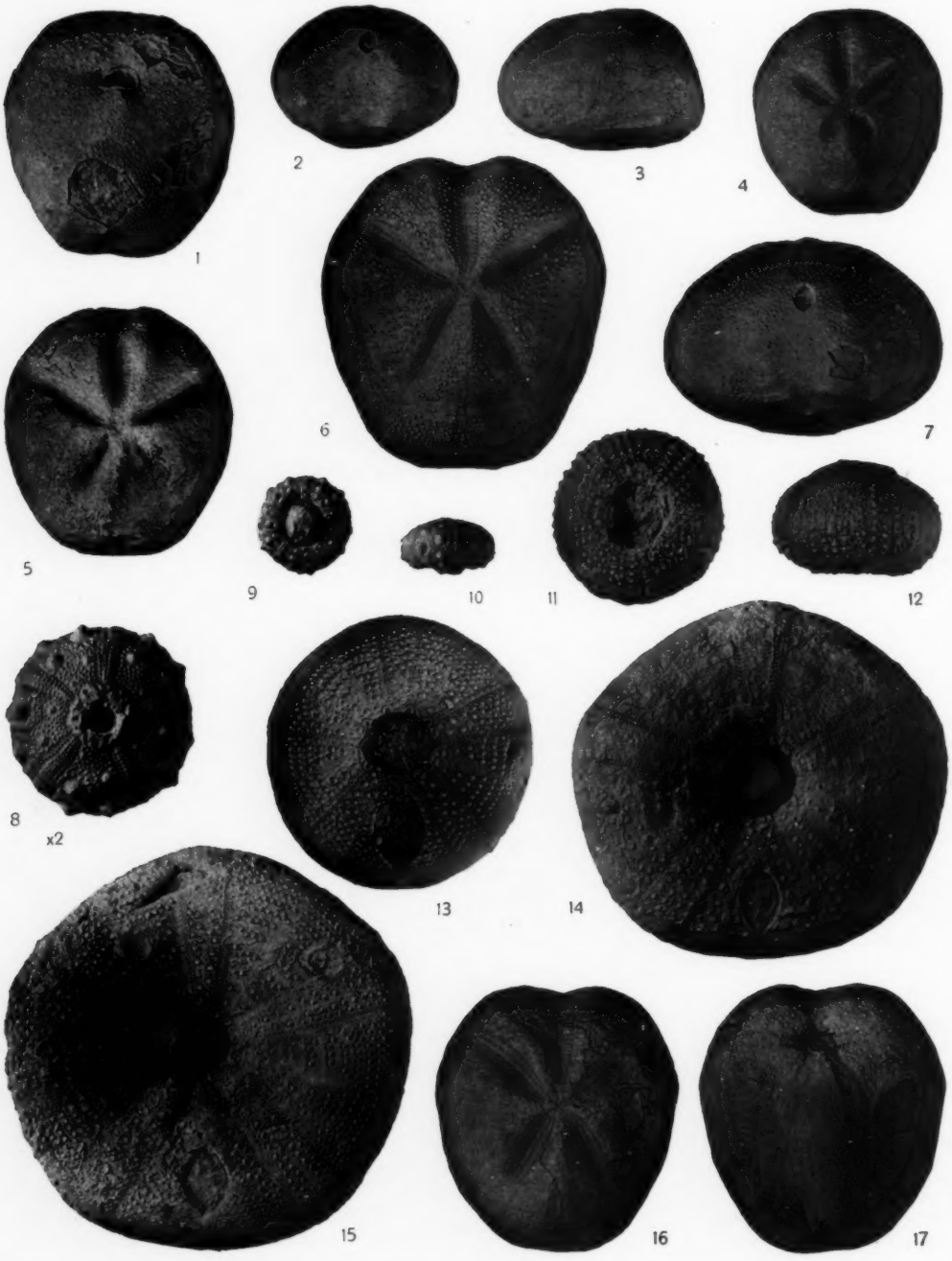
Remarks.—*Tetragramma streeruwitzi* may prove to be a synonym of *T. variolare*, the genotype. Its periproct may be a trifle smaller than that of the genotype, but in other respects the specimens from Texas are very similar to the figures of those from the Cenomanian of France. It can be distinguished from *P. malbosii* by its more even rows of tubercles, its smaller, less deeply

EXPLANATION OF PLATE 31

FIGS. *1, 2—Salenia mexicana* Schlüter. Bottom and top of USNM 103874, ×1. USGS 11842. Brazos River 4 miles northwest of Whitney, Texas; Fredericksburg group. (p. 204)
3—Salenia texana Credner. Top of USNM 103873, ×1. USGS 10200, Cibolo River 2½ miles west of crossing of Bulverde road, Bexar County, Texas; Trinity group: Glen Rose limestone. (p. 203)
4—Salenia volana Whitney. Top of USNM 8329c, ×1. Bexar County, Texas. (p. 204)
5—Cottaldia rotula Clark. Top of USNM 103876, ×1. First creek south of Manchaca, Texas; Washita group: upper part of Buda limestone. (p. 215)
6, 7—Orthopsis charltoni (Cragin). Top and bottom of holotype, USNM 32682, ×1. Limekiln south of Denison-Bonham road on Pawpaw Creek bluff, south of Denison, Texas; Washita group: Mainstreet limestone. (p. 214)
8, 9—Goniophorus scotti Lambert. Top and bottom of USNM 103877, ×2. Tarrant County, Texas, 1½ miles north of Texas Christian University; Washita group. (p. 202)
10–12—Clypeopygus angustatus (Clark). Top, right side, and bottom of type, USNM 103701 (JHU T 3009), ×1. Shoal Creek, Texas; Washita group. (p. 222)
13, 14—Loriolia clarki Cooke, n. name. Top and bottom of holotype, USNM 103702 (JHU 3006), ×1. Shoal Creek, Texas; Washita group. (p. 206)
15–17—Loriolia rosana Cooke, n. sp. Top, bottom, and side of holotype, USNM 103878, ×1½. USGS 10483, Turtle Creek, Kerr County, Texas; Trinity group: Glen Rose limestone? (p. 205)
18, 19—Phymosoma texanum (Roemer). Top and bottom of USNM 103871, ×1. USGS 17478, Dawson County, Texas, 12 miles east of Lamesa; Fredericksburg(?) group. (p. 209)
20, 21—Pedinopsis symmetrica (Cragin). Side and bottom of USNM 103960, ×1. USGS 2059, Hog Creek, 8 miles west of Waco, Texas; Washita group: Fort Worth limestone. (p. 211)
22—Phymosoma mexicanum Böse. Top of USNM 103872, ×1. South side of Rio Grande near El Paso, Texas, between the railroad bridge and the Initial Monument; Washita group. (p. 211)
23—Tetragramma streeruwitzi (Cragin). Top of larger cotype, ×1. Sierra Blanca Mountains, Texas; Washita group. (p. 208)
24—Goniopygus zitteli Clark. Top of cotype USNM 12234a, ×1. Round Rock, Texas; Fredericksburg group. (p. 201)



Cooke, Comanche Echinoids



Cooke, Comanche Echinoids

notched peristome, and its flatter shape. It bears a superficial resemblance to *Phymosoma texanum* and *P. mexicanum* but differs in its perforate tubercles, its smaller peristome, and its star-shaped, rather than pentagonal, apical system.

Genus PHYMOSOMA d'Archiac and Haime, 1853

Cyphosoma AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 4. Not MANNERHAIM, 1837.
Cyphosoma, AGASSIZ, 1840, Catalogus systematicus ectyporum echinodermatum, pp. 11, 19.
Cyphosoma, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 47.
Phymosoma D'ARCHIAC AND HAIME, 1853, Description des animaux fossiles de l'Inde, p. 197. For *Cyphosoma* Agassiz.
Phymosoma, DESOR, 1858, Synopsis des échinides fossiles, p. 86.
Cyphosoma, COTTEAU, 1864, Paléontologie française, Terrain crétacé, t. 7, p. 567
Cyphosoma, WRIGHT, 1870, British fossil Echinodermata from the Cretaceous formations, vol. 1, pt. 3, p. 128.
Cyphosoma, DUNCAN AND SLADEN, 1882, Palaeontologia Indica, ser. 14, vol. 1, pt. 3, fasc. 2, p. 31.
Phymosoma, POMEL, 1883, Classification méthodique et genera des échinides p. 90.
Phymosoma, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 222.
Phymosoma, COOKE, 1941, Jour. Paleontology, vol. 15, no. 1, p. 17.

Genotype, *Echinus milleri* Desmarest, 1825, = *Cidaris konigii* Mantell, 1822, from the Chalk of Kent, England, designated by Lambert and Thiéry (1910). This species has been figured by Cotteau (1864, p. 678, pls. 1167, 1168) and by Wright (1870, p. 131, pls. 23–26). It is a flattish, disc-shaped species with imperforate tubercles. Its ambulacral pores are arranged above the ambitus in two rows of pairs, six pairs to the ambulacral tubercle; on and below the ambitus they are arranged in single arcs of five and four pairs to the tubercle. The apical system is unknown; apparently it was very loosely attached, for it is wanting in all specimens. The scar marking its location is about as large as the peristome, pentagonal, with the posterior point somewhat longer than the others, probably marking the location of the periproct, which presumably opened adjacent to the shallow sulcus in the posterior interambulacral area. The peristome is circular, about one-third the diameter of the test, and has shallow branchial notches.

PHYMOSOMA TEXANUM (Roemer) Plate 31, figures 18, 19

Diadema texanum ROEMER, 1849, Texas, p. 393.
Cyphosoma texanum, ROEMER, 1852, Kreidebildungen von Texas, p. 82, pl. 10, figs. 6a–c.
Cyphosoma texanum (part), CONRAD in HALL, 1857, U. S. and Mexican Boundary Survey

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EXPLANATION OF PLATE 32

FIGS. *1–4—Hemiaster cranium* Cooke, n. sp. *1*, Bottom of paratype USNM 103891, ×1. USGS 19690 (Renfro collection W 1). *2-4*, Posterior end, left side, and top of holotype, USNM 103890, ×1. USGS 19691 (Renfro collection W 2), 3 miles northeast of down-town Fort Worth. Washita group: Weno limestone. (p. 226)

5—Hemiaster calvini Clark. Top of cotype, USNM 12241, ×1. Mouth of Shoal Creek, Austin, Texas; Washita group. (p. 225)

6, 7—Hemiaster comanchei Clark. Top and posterior end of holotype, USNM 103893 (JHU T 3012), ×1. Bed of Colorado River at Santa Monica Springs, about 10 miles west of Austin, Texas; Trinity group: Glen Rose limestone. (p. 223)

8–10—Pseudocidaris elegans (Clark). Top, ×2, bottom and side, ×1, of holotype, USNM 31196. USGS 2214, junction of Muddy and Clear Forks of Little Missouri River, Pike County, Arkansas, 3 miles west of Murfreesboro; Trinity group: Dierks limestone. (p. 200)

11, 12—Diademopsis (*Leptarbacia*) *arguta* (Clark). Bottom and side of USNM 31198 (holotype of *Micropsis lineatus* Clark), ×1. Cut on Bonham Railroad, Denison, Texas; Washita group: Grayson marl. (p. 213)

13—Holectypus (*Coenholectypus*) *planatus* Roemer. Bottom of USNM 103886, ×1. USGS 1558, west of creek about 9 miles northeast of Kerrville on road to Fredericksburg, Texas. (p. 217)

14—Holectypus (*Coenholectypus*) *transpecosensis* Cragin. Bottom of USNM 103887, ×1. USGS 1914, Sierra Blanca Mountains, pass between North and South Peaks; Washita group. (p. 218)

15—Holectypus (*Coenholectypus*) *castilloi* Cotteau. Bottom of USNM 103888, ×1. USGS 7608, San Marcos, Hays County, Texas, south-facing slope on grounds of State Normal School; Washita group: Georgetown limestone. (p. 218)

16, 17—Hemiaster whitei (Clark). Top and bottom of type, USNM 9732, ×1. Locality unknown. (p. 224)

Rept., vol. 1, pt. 2, p. 145, pl. 1, figs. 3a–c (after Roemer).

Phymosoma texanum, DESOR, 1858, Synopsis des échinides fossiles, p. 90.

Pseudodiadema texanum (part), CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 75.

Diplopodia texanum (part), CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 48. Not pl. 15, figs. 1a–f, nor pl. 16, figs. 1a–d (=*Tetragramma malbosii* (Agassiz)).

Cyphosoma volanum CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 147.

Cyphosoma texanum (part), CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 60, pl. 21, figs. 1f–g. Not pl. 21, figs. 1a–e (=*Tetragramma malbosii* (Agassiz)).

Cyphosoma volanum, CLARK, 1915, *idem*, p. 61, pl. 21, figs. 2a–b, 3.

?Cyphosoma volanum?, WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 95, pl. 20, fig. 1.

Phymosoma texanum, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 268.

Phymosoma volanum, LAMBERT, 1927, *idem*, p. 268.

Phymosoma texanum, ADKINS, 1928, Texas Univ. Bull. 2838, p. 278.

Phymosoma volanum, ADKINS, 1928, *idem*, p. 279.

Phymosoma texanum, LAMBERT, 1935, Soc. géol. France Bull., sér. 5, t. 5, p. 367.

Not *Phymosoma volanum* (Cragin). JONES, 1938, Geol. Soc. America Bull., vol. 49, no. 1, p. 131, pl. 13, figs. 2–4.

Occurrence.—TEXAS: Fredericksburg and San Saba River (type, *fide* Roemer); North Fork San Gabriel River at Georgetown (USNM 12232, 19115); gap between North and South Sierra Blanca Peaks, El Paso County (USNM 1813, T. W. Stanton); Coyote, Bosque County (USNM 2710, G. N. Phillipson); Taylors Bluff, Barton Springs, near Austin (USGS 130, R. T. Hill); base of cliff-forming ledge at top of Big Spring Mountain, Howard County (USGS 13151, T. W. Stanton and W. B. Lang); 12 miles east of Lamesa, Dawson County (USGS 17478, A. N. Sayre and R. R. Bennett); 1 mile east of Advance, 6 miles southwest of Poolville, Parker County (USGS 18572, Ralph Imlay); Main Street, half a mile east of depot, Denison, Grayson County (USGS 1457, R. T. Hill); M.K.&T. Ry. bridge on Big Elm Creek, Denton County (type of *Cyphosoma volanum* Cragin).

Geologic horizon.—Fredericksburg group; Washita group (rare).

Type.—Possibly at the university in Bonn, Germany. The type of *Cyphosoma volanum*, the property of the Texas Bureau of Economic Geology at Austin, is on temporary deposit at the United States National Museum.

Remarks.—This species appears to be a true *Phymosoma*, though the two rows of pore pairs on the upper surface are closer together and the peristome is much larger than in the specimens of the genotype from Kent, England, with which I have compared the specimens from Texas.

There has been much confusion as to this species. Conrad (1857) misidentified as *Cyphosoma texanum* a fragment (USNM 9838) of a *Tetragramma* from Leon Springs, Texas, but copied Roemer's original figures. Clark (1893) figured as *Cyphosoma texanum* a specimen of *Tetragramma taffi* (=*T. malbosii*). In 1915 he copied these figures and identified the original as USNM 9838, the same number as Conrad's fragment, which is still in the National Museum, though Clark's figured specimen has not been identified. Clark (1915, pl. 21, figs. 1f–g) increased the confusion by adding two figures of imperforate tubercles ostensibly representing the same individual as figures 1a–e though probably drawn from a *Phymosoma*. On the same plate he figured (figs. 2a–b), ostensibly as cotype A of *Cyphosoma volanum* Cragin, an individual from the mouth of Barton Creek at Austin, and the figures are natural size, not ×2 as stated. Really, there is only one type of *C. volanum*, a small individual from the *Vola* bed on Big Elm Creek, Denton County, Texas, which seems to have been the model for Clark's figure 3. This specimen came from the top of the Washita group (Buda limestone?). Whitney (1916) figured a fragment from the Buda limestone, and Hill found one twice as large as Cragin's type in the Pawpaw formation at Denison. These seem to be specifically identical with *Phymosoma texanum* from the Fredericksburg group.

The specimen from Coahuila, Mexico, figured as *Phymosoma volanum* by Jones (1938) is probably a *Loriolia* in which the perforations of the tubercles have become obliterated. Its mamelons are much smaller than those of *Phymosoma texanum*, and its poriferous zones are uniseral throughout.

PHYMOSOMA MEXICANUM Böse
Plate 31, figure 22

Phymosoma mexicanum BÖSE, 1910, Inst. geol. México Bol. 25, p. 158, pl. 33, figs. 7–10; pl. 34, fig. 3; pl. 35, figs. 1–3, 7, 8.
Phymosoma mexicanum, ADKINS, 1928, Texas Univ. Bull. 2838, p. 279.
Phymosoma mexicanum, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 458.

Occurrence.—MEXICO: Cerro Muleros, just above and slightly south of the Initial Monument of the U. S. and Mexican boundary Survey, near Ciudad Juarez (type, *fide* Böse).

TEXAS: South side of Rio Grande 4 miles west of El Paso (USNM 1689, E. A. Mearns); hillside east of dome-shaped mesa of Cerro San Antonio (USGS 2754, R. T. Hill and G. H. Girty); gap between North and South Sierra Blanca Peaks, El Paso County (USGS 1914); Phantom Hills (USNM 18886); 6 miles west of Kent, Culberson County (USGS 1928, T. W. Stanton); 2 miles west of Kent (USGS 1929, T. W. Stanton); 7 miles east of Kent (USGS 14250, T. W. Stanton and W. P. Popenoe); 15 miles north of Hovey, Pecos County (USGS 14342, N. H. Darton); fault near Spicewood Spring, Travis County (USGS 64, R. T. Hill); head of Nolan Creek (USNM 7107).

Geologic horizon.—Washita group.

Type.—Probably at the Instituto Geológico de México.

Remarks.—This species is very similar to *Phymosoma texanum*, from which it differs in its outline, which is usually subpentagonal, not circular. None of the specimens in the United States National Museum, which were identified by Clark as *Cyphosoma texanum*, are well preserved, but their shape appears to be distinctive.

Family ECHINIDAE Agassiz
Genus PEDINOPSIS Cotteau, 1863

Pedinopsis COTTEAU, 1863, Congrès sci. France Mém., session 28, t. 3, p. 176.
Pedinopsis, COTTEAU, 1864, Paléontologie française, Terrain crétacé, t. 7, p. 527.
Pedinopsis, COTTEAU, 1867, *idem*, p. 826.
Pedinopsis, WRIGHT, 1868, British fossil Echinodermata from the Cretaceous formations, p. 113.
Pedinopsis, POMEL, 1883, Classification méthodique et genera des échinides, p. 103.
Dumblea CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, p. 2, p. 149.
Pedinopsis, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 190.
Dumblea, LAMBERT AND THIÉRY, 1910, *idem*, p. 207.
Dumblea, LAMBERT AND THIÉRY, 1925, *idem*, fasc. 8, p. 566.

Genotype, *Pedinopsis meridanensis* Cotteau (1863, p. 177; 1864, p. 528, pls. 1125, 1126), by monotypy. This species is attributed to the Neocomian of Aude, France, by Cotteau. His figures indicate that its poriferous zones consist of two straight rows of transverse pore pairs, which alternate in location and become crowded near the notched peristome. Its even, perforated, faintly crenulated tubercles are set in nearly straight rows. Its ambulacral plates have six pairs of pores and are proportionately higher than the interambulacral plates, which are very wide, short, and have as many as five nearly equal tubercles. Its deeply notched peristome is about one-third the total width. The figures of the genotype do not show the apical system, but the American species *P. symmetrica* (Cragin) has five L-shaped ocular plates, of which only the right posterior plate reaches the periproct, and five perforated genital plates, of which the right anterior, containing the madreporite, is the largest.

The arrangement of its pore pairs in two staggered rows readily distinguishes *Pedinopsis* from *Micropedina*, in which the pore pairs are arranged in oblique groups of three, and in which none of the ocular plates reach the periproct. The crenulation of the tubercles of *Pedinopsis* is not a satisfactory basis of separation, because it may be very faint or even obliterated.

PEDINOPSIS SYMMETRICA (Cragin)
Plate 31, figures 20, 21

Dumblea symmetrica CRAGIN, 1893, Texas Geol Survey Ann. Rept. 4, pt. 2, p. 150, pl. 24, fig. 12; pl. 25, figs. 4–7; pl. 27, fig. 1.
Pedinopsis symmetrica, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 64, pl. 23, figs. 1a–h.
Micropedina olisiponensis (Forbes). LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 267.
Micropedina symmetrica, ADKINS, 1928, Texas Univ. Bull. 2838, p. 276.
Dumblea symmetrica, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 457, pl. 62, figs. 17–20.

Occurrence.—TEXAS: Sierra Blanca Moun-

tains (type, *fide* Cragin); pass between North and South Sierra Blanca Peaks (USGS 1813, 1914, T. W. Stanton); 5 miles west of Kent, Culberson County (USGS 1936, 1938, T. W. Stanton); 165–185 feet above base of hill south of highway 6 miles east of Kent (USGS 14251, T. W. Stanton and W. P. Popenoe); 10 miles south of McCamey, Upton County, south of Pecos River (USGS 14314, N. H. Darton); Hog Creek 8 miles west of Waco, McClennan County (USGS 2059); lat. 29°52′, long. 103°8′, near center of Hood Springs quadrangle (USGS 13891, N. H. Darton); south side of Rio Grande near El Paso, between the railway bridge and the Initial Monument (Dr. E. A. Mearns); 0.5 mile north of Meadowbrook Country Club, Fort Worth (USGS 19687, Renfro collection); 5 miles east of down-town Fort Worth (USGS 19691, Renfro collection).

Geologic horizon.—Washita group.

Type.—Geological Survey of Texas, Austin (*fide* Clark, 1915).

Remarks.—This species, the genotype of *Dumblea* Cragin, closely resembles *Pedinopsis meridanensis* Cotteau as illustrated by Cotteau (1864, pls. 1125, 1126), though his drawings show more conspicuous crenulations on the tubercles, which are very faint on all the specimens from Texas. *Dumblea* was maintained as a valid genus by Lambert and Thiéry (1925, p. 566) on the mistaken supposition that its tubercles are not crenulate. Lambert (1926, p. 267) put *Dumblea symmetrica* in the synonymy of *Echinus olisiponensis* Forbes, the genotype (under the name *Codiopsis cotteaui* Coquand) of *Micropedina* Cotteau (1867, p. 822); but the ambulacral pore pairs of that species as figured by Cotteau (1867, pl. 1197) are arranged in diagonal groups of three, and none of its ocular plates reach the periproct.

Pedinopsis yarbroughi Ikins

Pedinopsis yarboroughi Ikins, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 62, pl. 4, figs. 3a–c.

Pedinopsis engerrandi, Ikins, 1940, *idem*, p. 62, pl. 4, figs. 2a–c.

Occurrence.—Texas: Dies ranch on the Pond Springs-Anderson Mill road, Travis County (type of *P. yarbroughi*); Anderson Mill road just west of Marshall Ford Dam road, Travis County (type of *P. engerrandi*).

Geologic horizon.—Fredericksburg group: lower beds of the Walnut clay.

Type.—University of Texas, Austin.

Remarks.—According to the descriptions of their author, the only difference between these two nominal species, which I know only from their figures, lies in the flatter bottom of *P. engerrandi*, a difference that is probably either an individual variation or the result of distortion. *Pedinopsis symmetrica* (Cragin) shows similar variation. Although they appear to be very similar to *P. symmetrica*, with which they were not compared by Ikins, they are tentatively treated as a valid species, because they were found at a different stratigraphic level.

Genus Diademopsis Desor, 1855

Diademopsis Desor, 1855, Synopsis des échinides fossiles, p. 79.

Diademopsis, Cotteau and Triger, 1869, Échinides du Département de la Sarthe, p. 398.

Diademopsis, Desor and de Loriol, 1871, Échinologie helvétique, Période jurassique, p. 183.

Diademopsis, Cotteau, 1882, Paléontologie française, Terrain jurassique, t. 10, pt. 2, p. 439.

Diademopsis, Pomel, 1883, Classification méthodique et genera des échinides, p. 99.

Hemipedina (*Diademopsis*), Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 198.

Genotype, *Diadema seriale* Agassiz, from the Jurassic of France, designated by Cotteau (1882, p. 443). It has been figured by Desor (1855, p. 79, pl. 14, figs. 12–14) and by Cotteau (1882, p. 440, pls. 378–380). Desor's figure, which may not be accurate, shows a large apical system in which three of the oculars nearly or quite reach the circular periproct. Cotteau's (1882, pl. 380, fig. 14) figure of *D. minima* shows the two posterior oculars penetrating to the periproct. The ambulacral areas of the genotype are very narrow; the pore pairs are uniserial and straight or staggered, but they are separated into slightly oblique groups of three on the lower side. There are two rows of small perforate smooth tubercles in each ambulacral area, and six rows of larger tubercles on the ambitus in each interambulacral area, but only the two rows next to the two outer rows persist to the apex.

Diademopsis appears to be amply distinct from *Hemipedina* Wright, 1855, which it superficially resembles. The apical system of *Diademopsis serialis* occupies less than one-fourth of the diameter, whereas that of *Hemipedina etheridgii* occupies nearly one-third; yet the periproct of *D. serialis* is the larger, and the genital plates are much smaller and permit the oculars almost to reach the periproct, whereas the apical system of *Hemipedina* is plainly dicyclic. The interambulacral plates of *Diademopsis* are not as tall and have three tubercles at the ambitus, whereas the corresponding plates of *Hemipedina* have only one. The notches on the peristome of *Diademopsis* are wider and shallower.

Subgenus LEPTARBACIA Clark, 1915

Leptarbacia CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 53.
Leptarbacia, LAMBERT AND THIÉRY, 1925, Nomenclature raisonnée des échinides, fasc. 8, p. 565.
Leptarbacia, SMISER, 1933, Jour. Paleontology, vol. 7, no. 2, pl. 138.

Genotype, *Leptarbacia arguta* Clark, by monotypy.

Leptarbacia has a rather small oculogenital ring in which the two posterior ocular plates reach the periproct. Its ambulacral plates are nearly as high as wide, and each has one primary crenulated tubercle adjacent to the poriferous zone, in which there are generally four pairs of pores to the compound plate. The poriferous zones are uniserial and are straight in the ambital region and staggered near the apex. The interambulacral plates of the genotype are nearly three times as wide as high; those of the ambitus have one central primary tubercle, those below have three, the outer two somewhat higher on the plate than the central.

The chief apparent difference between *Leptarbacia* and *Diademopsis, s.s.*, appears to be the smooth tubercles of the latter, as described. Also *Diademopsis serialis* may have a proportionately larger apical system, and the notches of its peristome may be wider and less acute.

The ambulacral plates of *Orthopsis* are proportionately much shorter, its oculogenital ring is dicyclic, and its tubercles are smooth. The unique genotype of *Microdiadema* Cotteau (1883), *Arbacia richeriana* Cotteau (1885, p. 885, pl. 425, figs. 5–9; pl. 152, figs. 5–10), has a dicyclic oculogenital ring, it is very small, its base is concave, and its peristome is proportionately larger.

DIADEMOPSIS (LEPTARBACIA) ARGUTA Clark
Plate 32, figures, 11, 12

Leptarbacia argutus CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 53, pl. 16, figs. 1a–f.
Micropsis lineatus CLARK, 1915, *idem*, p. 63, pl. 25, figs. 1a–c.
Echinopsis lineata, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Echinopsis lineata, ADKINS, 1928, Texas Geol. Survey Bull. 2838, p. 274.
Leptarbacia arguta, ADKINS, *idem*, p. 275.
Leptarbacia arguta, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 457, pl. 62, figs. 1–3.
?Cottaldia rotula Clark. IKINS AND CLABAUGH, 1940, Bull. Am. Paleontology, vol. 26, no. 96, p. 271, pl. 40, figs. 5a–c.

Occurrence.—TEXAS: Fort Worth (type, Wolf Holstein); cut on Bonham Railroad, southeast edge of Denison, Grayson County (type of *Micropsis lineata*, USNM 31198, R. T. Hill, T. W. Stanton, and Frank Burns); near Buck Hill, 50 miles south of Alpine, Brewster County (*fide* Smiser); ?Bushwhack Creek, 10 miles southwest of Kerrville (*fide* Ikins and Clabaugh).

Geologic horizon.—Washita group; Grayson marl (type of *M. lineata*), Del Rio clay [=Grayson marl] (*fide* Smiser).

Type.—USNM 103703, deposited by Johns Hopkins University, T. 3004; type of *Micropsis lineata*, USNM 31198.

Remarks.—The type of *Leptarbacia arguta* is a small corroded specimen from which the two right-hand genital plates and the intervening ocular plate are wanting. Part of the base is broken off, and the remaining part is flattened by crushing. Clark's drawings represent fairly well such features as are shown. The peristome is circular, with moderately sharp notches, and it occupies about one-third of the total diameter. The tubercles, though badly worn, show indications of perforations and crenulations.

The type of *Micropsis lineata* (pl. 32, figs. 11, 12) is not much corroded, but more than half of the top, including the oculogenital ring, is broken off. The sculpture, because of its better state of preservation, is much rougher than that of *L. arguta*, but the features are the same. The base is not at all concave, though it is flatter than the

upper part. Some of its tubercles are plainly crenulated, and their perforations are conspicuous. It cannot be a *Micropsis* (genotype, *Micropsis desori* Cotteau) because its tubercles are perforated and its ambulacral pores are not arranged in arcs. It is not an *Echinopsis* (genotype, *Echinus elegans* Des Moulins) because it has too many rows of tubercles and its peristome is not deeply enough notched.

Genus ORTHOPSIS Cotteau, 1863

Orthopsis COTTEAU, 1863, Paléontologie française, Terrain crétacé, t. 7, p. 374.
Orthopsis, COTTEAU, 1864, *idem*, p. 550.
Orthopsis, DE LORIOL, 1873, Échinologie helvétique, pt. 2, p. 135.
Orthopsis, POMEL, 1883, Classification méthodique et genera des échinides, p. 100.
Orthopsis, COTTEAU, 1885, Paléontologie française, Terrain jurassique, t. 10, p. 875.
Orthopsis, LAMBERT AND THIÉRY, 1910, Nomenclature raissonée des échinides, fasc. 3, p. 199.

Genotype, *Cidarites miliaris* d'Archiac, common in the Senonian of France, designated by Cotteau (1864, p. 563). As figured by Cotteau (1864, p. 558, pl. 1131), the genotype of *Orthopsis* is rather small (20 mm. in diameter), circular, about half as tall as wide. It has five large perforated genital plates completely enclosing the central periproct, which is slightly eccentric posteriorly. Its ambulacral areas are about half as wide as the interambulacral areas. Its pores form a single straight line from the apex to the peristome, and there are three pairs to each compound plate. The peristome is represented as circular, variable in width, averaging about one-third the diameter of the test, and moderately notched. Two rows of medium-sized, perforated, smooth tubercles extend the full length of the test in each area, and there are four additional rows on the middle and basal parts of the interambulacral areas. The remainder of the surface is covered with small tubercles or granules. It appears to differ from the Jurassic *Pedina etheridgii* Wright (1854, p. 315, pl. 11, figs. 5a–c), the genotype of *Hemipedina* Wright (1855, p. 95), in its proportionately smaller apical system, in which the periproct is proportionately larger and lies somewhat back of the center, whereas in *Hemipedina etheridgii* the periproct is small and central. Its madreporite is large and swollen and occupies nearly all of the right anterior genital plate, whereas in *Hemipedina* the madreporite is small and occupies only part of the plate. *Orthopsis miliaris* has more primary tubercles than *Hemipedina etheridgii*, which has only one on each interambulacral plate. Its interambulacral plates are shorter and wider.

ORTHOPSIS OCCIDENTALIS Cragin

Orthopsis occidentalis CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, pl. 160, pl. 25, figs. 1–3; pl. 27, fig. 2.
Orthopsis occidentalis, CLARK, 1915, U. S. Geol. Survey Mon. 54, pl. 17, figs. 1a–g.
Orthopsis occidentalis, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 266.
Orthopsis occidentalis, ADKINS, 1928, Texas Univ. Bull. 2838, p. 276.
Orthopsis occidentalis, SMISER, 1931, Jour. Paleontology, vol. 7, p. 140, pl. 18, figs. 11, 12 (after Clark).

Occurrence.—TEXAS: Sierra Blanca Mountains, Hudspeth County (*fide* Cragin).

Geologic horizon.—Probably Washita group.

Type—Geological Survey of Texas, Austin (*fide* Clark).

Remarks.—The type of this species, as figured by Clark, has a proportionately smaller peristome than that of *Orthopsis charltoni* (Cragin), which is less than half as large. Otherwise, the two species appear to be very similar.

ORTHOPSIS CHARLTONI (Cragin)
Plate 31, figures 6, 7

Hemipedina charltoni CRAGIN, 1894, Colorado College Studies, vol. 5, p. 50.
Hemipedina charltoni, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 57.
Orthopsis planulata CLARK, 1915, *idem*, p. 54, pl. 16, figs. 2a–c.
Orthopsis planulata, ADKINS, 1928, Texas Univ. Bull. 2838, p. 276.
Orthopsis planulata, SMISER, 1931, Jour. Paleontology, vol. 7, p. 140, pl. 18, fig. 10 (after Clark).

Occurrence.—TEXAS: Limekiln south of Denison-Bonham road on Pawpaw Creek bluff, east of Denison (type, USNM 32682, F. W. Cragin); cut on Bonham road, southeastern edge of Denison (type of *O. planulata*, *fide* Clark).

Geologic horizon.—Washita group: Type of *O. charltoni* from Main Street limestone; *O. planulata* from Grayson marl (*fide* Clark; the label is marked "Main Street limestone" in pencil).

Type.—USNM 32682. Type of *O. planulata*, USNM 103708, deposited by Johns Hopkins University, T. 3005.

Remarks.—The periproct appears to occupy proportionately more of the apical area in *Orthopsis charltoni* than in the genotype, with the result that one or more of the ocular plates may border it. The sutures in the apical system of the type are indistinct.

Genus COTTALDIA Desor, 1856

Cottaldia DESOR, 1856, Synopsis des échinides fossiles, fasc. 3, p. 113.
Cottaldia, COTTEAU, 1866, Paléontologie française, Terrain crétacé, t. 7, p. 788.
Cottaldia, COTTEAU AND TRIGER, 1869, Échinides du Département de la Sarthe, p. 404.
Cottaldia, WRIGHT, 1874, British fossil Echinodermata from the Cretaceous formations, vol. 1, p. 186.
Cottaldia, POMEL, 1883, Classification méthodique et genera des échinides, p. 83.
Cotteaudia, LAMBERT AND THIÉRY, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 229. Unjustified rectification of spelling.

Genotype, *Echinus granulosus* Münster, 1826, = *Echinus benettiae* König, 1820, from the Cenomanian of Europe, designated by Lambert and Thiéry, 1910. This species has been figured by Desor (1856, pl. 19, figs. 1–3), Cotteau and Triger (1859, p. 155, pl. 28, figs. 13–18), Cotteau (1866, p. 789, pl. 1193; pl. 1194, figs. 1–10), and Wright (1874, p. 187, pl. 45, figs. 1–3).

Wright's figures of the genotype show a globular test with a dicyclic apical system, straight single rows of transverse pore pairs, apparently three or four pairs to an ambulacral plate, which is proportionately much higher than the very short, wide interambulacral plates, and a large, very weakly notched peristome. The tubercles are small, imperforate, arranged in single straight rows of as many as 11 on a single interambulacral plate, and in a staggered row of four or less on each ambulacral plate. There is a row of smooth granules on each side of the rows of tubercles.

The original orthography of *Cottaldia* must be retained under Article 19 of the International Code of Zoological Nomenclature.

COTTALDIA ROTULA Clark
Plate 31, figure 5

Cottaldia rotula CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 57, pl. 20, figs. 1a–d.
Cottaldia rotula, WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 93, pl. 18, figs. 1–10; pl. 19, figs. 1, 2.
Cotteaudia benettiae (König). LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 268.
Cottaldia? rotula, ADKINS, 1928, Texas Univ. Bull. 2838, p. 279.
Cottaldia? rotula, SMISER, 1933, Jour. Paleontology, vol. 7, no. 2, p. 145, figs. 16, 17 (after Clark).
Pseudodiadema rotula, SMISER, 1936, *idem*, vol. 10, no. 6, p. 455, pl. 62, figs. 4–6, 10.

Occurrence.—TEXAS: Shoal Creek, Travis County (type; USNM 12241); first creek south of Manchaca (F. L. Whitney); about 50 miles south of Alpine, just east of the Terlingua road, across from Buck Hill (*fide* Smiser, 1936); yellow beds one-eighth mile south of Dryden, Terrell County (USGS 14304, N. H. Darton); 5 miles west of Kent (USGS 1936, T. W. Stanton).

Geologic horizon.—Washita group: Buda limestone.

Types.—USNM 103705, 103705a, deposited by Johns Hopkins University, T 3007.

Ikins and Clabaugh's (1940, p. 271, pl. 40, figs. 5a–c) identification of this species from the Edwards limestone must be erroneous, for their figures plainly show staggered or biserial pore pairs, whereas the pore pairs of *Cottaldia rotula* are uniserial, in very straight lines. Their figures probably represent *Diademopsis arguta* (Clark).

Genus CODIOPSIS Agassiz, 1840

Codiopsis AGASSIZ, 1838, Mon. d'échinodermes, livr. 1, p. 4. Name only.
Codiopsis, AGASSIZ, 1840. Catalogus systematicus ectyporum Echinodermatum, pp. 13, 19.
Codiopsis, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 53.
Codiopsis, DESOR, 1858, Synopsis des échinides fossiles, p. 112.
Codiopsis, COTTEAU, 1866, Paléontologie française, Terrain crétacé, t. 7, p. 744.
Codiopsis, COTTEAU AND TRIGER, 1869, Échinides du Département de la Sarthe, p. 404.
Codiopsis, POMEL, 1883, Classification méthodique et genera des échinides, p. 82.
Codiopsis, LAMBERT AND THIÉRY, 1914, Nomenclature raisonnée des échinides, fasc. 4, p. 263.

Genotype, *Echinus doma* Desmarest, from the Cenomanian of France, Belgium, and Germany, by monotypy. This species has been figured by Desor (1858, pl. 19, figs. 15–17), Cotteau (1866, pls. 1191, 1192, figs. 1–11), and by Cotteau and Triger (1869, p. 162, pl. 29, figs. 1–8). It is tall, subglobu-

lar, with a slightly flattened base and a subpentagonal outline. It has five nearly equal perforated genital plates completely enclosing the circular periproct. Genital and ocular plates are decorated with granules. The ambulacral pore pairs are uniserial except near the peristome, where they are irregularly multiplied. The large imperforate tubercles are confined to the region surrounding the peristome in a manner suggestive of a floscelle. The upper surface is shagreened and is decorated with scattered granules. The peristome is variously represented as subpentagonal or circular.

CODIOPSIS TEXANA Whitney

Codiopsis texana WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 91, pl. 17, figs. 1–4; pl. 20, fig. 2.
Codiopsis texanus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 280.
?Codiopsis sellardsi IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 60, pl. 4, figs. 1a–c.

Occurrence.—TEXAS: Austin (type, *fide* Whitney); Seven Mile Mesa, near Fort Stockton (type of *C. sellardsi*, *fide* Ikins).

Geologic horizon.—Washita group: top of lower part of Buda limestone (*fide* Whitney).

Remarks.—The figures of the type of this species are so similar to those of the genotype that *Codiopsis texana* might well be a synonym of *C. doma*. The distinguishing features of *C. sellardsi* are said to be its elongate, oval peristome and its more globular form. Neither of these features is reliable for drawing specific distinctions. The peristome of the genotype seems to range in shape from nearly circular to pentagonal.

Family HOLECTYPIDAE
Genus HOLECTYPUS Desor, 1842

Holectypus DESOR, 1842, Mon. d'échinodermes, livr. 3, pp. 6, 92.
Holectypus, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinides (reprint), p. 87.
Holectypus, DESOR, 1858, Synopsis des échinides fossiles, p. 168.
Holectypus, COTTEAU, 1861, Paléontologie française, Terrain crétacé, t. 7, p. 42.
Holectypus, COTTEAU, 1873, *idem*, Terrain jurassique, t. 9, p. 404.
Holectypus, WRIGHT, 1875, British fossil Echinodermata from the Cretaceous formations, p. 231.
Holectypus, POMEL, 1883, Classification méthodique et genera des échinides, p. 75.

Genotype, *Echinites depressus* Leske, 1778, first species, designated by Cotteau (1873, p. 406), very common in the Jurassic of Europe. It has been described and figured by Cotteau (1873, p. 413, pl. 103, figs. 8–14; pls. 104, 105). *Holectypus depressus* is represented as a medium-sized circular to subpentagonal echinoid with a more or less elevated upper surface and a flattened base, which is somewhat depressed around the peristome. The apical system has five genital plates, but the posterior plate is not perforated. The madreporite is large and swollen and occupies the central part of the apical system, where the periproct would be in a conventional regular echnoid. The ambulacral pore pairs are uniserial throughout. The peristome is central, moderately notched, and possibly a little wider than long. The periproct is large, oval, and basal.

Holectypus shows many features of the conventional regular echinoid, but its periproct is completely outside of the apical system. It differs from the conventional irregular echinoid in having five genital plates, a notched peristome, and dominantly radial symmetry.

Holectypus was originally described as a division or subgenus of *Discoidea*, from which it differs in its lack of internal buttresses, whence the name *Holectypus*, meaning "undivided cast." It was raised to the rank of genus in 1847. *Holectypus* is divisible into two subgenera, *Holectypus, s.s.*, with four genital pores, restricted to the Jurassic and *Coenholectypus*, with five genital pores, restricted to the Cretaceous.

Subgenus COENHOLECTYPUS Pomel, 1883

Coenholectypus POMEL, 1883, Classification méthodique et genera des échinides, p. 75.

Type species, *Discoidea macropyga* Agassiz, 1836, first species, designated by Lambert (1828, p. 20), from the Lower Cretaceous (Neocomian) of Europe. This species has been described and figured by Cotteau (1861, p. 44, pl. 1014, figs. 1–14; pl. 1015, figs. 1–4). All five of its genital plates are perforated, and they are separated by the ocular plates, which penetrate to the madreporite in a sort of monocyclic arrangement, whereas those of *Holectypus depressus* are dicyclic. Its periproct is large, oval, and occupies most of the space between the peristome and the ambitus. The edge of the periproct is visible from behind.

Pomel describes *Coenholectypus* as follows:

Ce sont des *Holectypus* à 5 plaques génitales perforées, dont la madréporique est souvent très prédominante sur les autres, dont le péristome, en général un peu plus enfoncé, a des entailles branchiales bien plus petites, un peu comme dans *Discoidea*. Les especes sont des terrains crétacés: *H. macropygus, H. serialis, H. cenomanensis, H. turonensis, H. portentosus, H. excisus, H. chauveneti, H. julieni, H. subcrassus.*

HOLECTYPUS (COENHOLECTYPUS) PLANATUS Roemer

Plate 32, figure 13

Holectypus planatus ROEMER, 1852, Kreidebildungen von Texas, p. 84, pl. 10, figs. 2a–g.
Holectypus planus GIEBEL, 1853, Naturwiss. Ver. Halle Jahresber. 1852, p. 373.
Holectypus planatus, CONRAD, 1857, U. S. Mex. Boundary Survey Rept., vol. 1, pt. 2, p. 145, pl. 1, figs. 4a–f.
Holectypus planatus, DESOR, 1858, Synopsis des échinides fossiles, p. 174.
Holectypus cenomanensis GUÉRANGER, 1859, in COTTEAU AND TRIGER, Échinides du Département de la Sarthe, p. 173, pl. 30, figs. 5–10.
Holectypus cenomanensis, COTTEAU, 1861, Paléontologie française, Terrain crétacé, t. 7, p. 53, pl. 1016, figs. 8–13.
Holectypus planatus, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 159.
Holectypus planatus, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 58, pl. 23, figs. 2a–f.
Holectypus planatus (part), CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 65, pl. 25, figs. 2a–f (type of *H. engerrandi* Lambert), 3a–c. Not pl. 26, figs. 1a–e (type of *H. charltoni* Cragin = *H. castilloi* Cotteau).
Holectypus planatus, ADKIN AND WINTON, 1920, Texas Univ. Bull. 1945, p. 50, pl. 9, fig. 2.
Holectypus planatus, WINTON, 1925, *idem*, Bull. 2544, p. 48, pl. 13, fig. 6.
Holectypus planatus, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 268.
Holectypus engerrandi LAMBERT, 1927, *idem*, p. 269.
Holectypus planatus, ADKINS, 1928, Texas Univ. Bull. 2938, p. 282, pl. 8, fig. 5; pl. 14, fig. 6.
Holectypus cf. *H. planus*, ADKINS, 1928, *idem*, pl. 282, pl. 3, fig. 2.
Holectypus engerrandi, ADKINS, 1928, *idem*, p. 281.
Holectypus planatus, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 460, pl. 62, figs. 8, 9, 11.
Holectypus engerrandi, SMISER, 1936, *idem*, p. 460, pl. 62, figs. 21–24.
Holectypus adkinsi SMISER, 1936, *idem*, p. 461, pl. 62, figs. 12–15.

Occurrence.—TEXAS: Near Fredericksburg (USNM 32092); hill about 3 miles north-northeast of Fredericksburg (USGS 1563, T. W. Stanton); canyon 7 miles from Kerrville (C. L. Hopkins); Turtle Creek, Kerr County (USGS 10483, C. Habecker); Guadalupe River 3½ miles west of Kerrville (USGS 1622, T. W. Vaughan and T. W. Stanton); west of creek about 9 miles northeast of Kerrville on road from Fredericksburg (USGS 1558, R. T. Hill); about 3 miles southwest of Fredericksburg on road to Kerrville (USGS 1627, R. T. Hill and T. W. Stanton); The Gap, near Austin (USGS 55, 57, R. T. Hill); Bee Caves Road 9 or 10 miles from Austin (USGS 53, 80, 83, R. T. Hill); Walnut clay, 5¾ miles northwest of Austin on Bee Cave Road (USGS A. N. Sayre); about 12 miles northwest of Austin (USGS 1625, R. T. Hill and T. W. Stanton); 21 miles west of Austin (USGS 56, R. T. Hill); Bear Creek near Peter Smith's, near Hays and Travis County line (USGS 61, R. T. Hill and T. W. Stanton); Cow Creek, Travis County (USNM 12236, figured by Clark, 1915); road 2 miles northeast of Burnet (USGS 1800, T. W. Stanton); Post Mountain 1 mile west of Burnet, 50 feet below summit (USGS 13207, T. W. Stanton; USGS 1798); west side Shaner's ranch, 3 miles west of Leon Springs, Bexar County (USGS 63, R. T. Hill); Liberty Hill, Williamson County (USNM 12240); S. Llano River (USNM 9608, 9609, R. T. Hill); Phantom Mills (USNM 18887, F. H. Mitchell); 30 feet below top of mesa 10 miles east of Sweetwater, Nolan County (USGS 13168, T. W. Stanton and W. B. Lang); Menard (USGS 11858, T. W. Stanton and J. A. Udden); 12 miles east of Lamesa, Borden County (USGS 17478, A. N. Sayre); north side of wagon road 1 mile north of Twin Buttes, 8 miles west of San Angelo (USGS 11857, T. W. Stanton and J. A. Udden); east bank of east fork of Nueces River 2 miles north of Round Mountain in northeast corner of Brackett quadrangle, by railroad track, 25 feet above river (USGS 13628, T. W. Stanton and N. H. Darton); Walnut clay, near Deadmans cut about 10 miles west of Odessa, Ector County (T. W. Stanton and W. B. Lang); 20 miles southwest of Gainesville (USGS 1502).

Geologic horizon.—Fredericksburg group: Comanche Peak limestone and Walnut clay. Trinity group: Glen Rose limestone.

Remarks.—*Holectypus planatus* appears to be the most common of the three valid

Comanche species. It did not grow so large as the other two, and it is further distinguished by the great length of its periproct, which extends almost from the peristome to the margin. Like most echinoids, the shape of its test is rather variable. The horizontal outline ranges from nearly circular to subpentagonal, and the vertical profile ranges from that of a low, evenly rounded dome to that of a higher, subconical shape.

Holectypus planus Giebel, known only from the description, is almost certainly merely a variety of *H. planatus*. *H. engerrandi* Lambert was named from an imperfect drawing of a characteristic *H. planatus*. *H. adkinsi* is merely an obese variety. *H. cenomanensis* Guéranger, from Europe and northern Africa, is placed in the synonymy by Lambert (1927, p. 268), who compared specimens of it with American specimens. Cotteau's figures closely resemble the American form. As the features that distinguish *H. cenomanensis* from *H. macropygus* (Agassiz, 1836) are not obvious from Cotteau's drawings, *H. planatus* may prove to be a junior synonym of *H. macropygus*.

HOLECTYPUS (COENHOLECTYPUS) CASTILLOI Cotteau

Plate 32, figure 15

Holectypus castilloi COTTEAU, 1890, Soc. géol. France Bull., sér. 3, t. 18, p. 295, pl. 1, figs. 1–8.
Holectypus charltoni CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 158, pl. 24, figs. 8, 9.
Holectypus planatus Roemer (part). CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 65, pl. 26, figs. 1a–e. These figures represent the same specimen as Cragin's figures of *H. charltoni*. Not pl. 25, figs. 2–4.
Holectypus limitis Böse. ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 51, pl. 9, figs. 1, 3.
Holectypus limitis Böse. WINTON, 1925, *idem*, Bull. 2544, p. 60, pl. 13, fig. 7.
Holectypus castilloi, ADKINS, 1928, *idem*, Bull. 2938, p. 282.
Holectypus charltoni, ADKINS, 1928, *idem*, Bull. 2838, p. 283, pl. 8, fig. 8.
Holectypus limitis Böse. ADKINS, 1928, *idem*, Bull. 2838, p. 282, pl. 8, fig. 7; pl. 14, fig. 7 (after Winton, 1925, pl. 13, fig. 7).

Occurrence.—MEXICO: Jalpa, Jalisco (type, Antonio del Castillo, *fide* Cotteau).

TEXAS: San Marcos, Hays County, south-facing slope on grounds of State Normal School, lower 15–25 feet of section (USGS 7608, L. W. Stephenson); Tarrant County at crossing of Deer Creek and Crowley road about 4 miles south of Baptist Theological Seminary, Fort Worth (USGS 18533, Ralph Imlay); 7 miles north of Handley; Rio Grande, vicinity of Del Rio, Val Verde County, top 50 feet of the Georgetown limestone (USGS 13976, W. G. Kane); Roanoke, Denton County, on Highway 114, just west of underpass (USGS 18521, Ralph Imlay); 2 miles northeast of Roanoke; Deer Creek about 9 miles south of Fort Worth (USGS 11743, T. W. Stanton and Gayle Scott); one-half mile north of Meadowbrook Country Club near Fort Worth (USGS 19687, Renfro collection); north of the 3,000 block of Young Avenue, Fort Worth (USGS 19690, Renfro collection).

Geologic horizon.—Washita group: Main Street limestone, Weno limestone, and equivalents.

Remarks.—Full-grown specimens of *Holectypus castilloi* are larger than *H. planatus;* their periproct is proportionately much smaller, occupying only about one-third of the space between the peristome and the margin. The periproct is generally somewhat smaller than that of *Holectypus transpecosensis* and is farther from the peristome. The diameter of the peristome is less than that of either *H. planatus* or *H. transpecosensis*.

HOLECTYPUS (COENHOLECTYPUS) TRANSPECOSENSIS Cragin

Plate 32, figure 14

Holectypus transpecosensis CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 160, pl. 27, figs. 3–5.
Holectypus limitis BÖSE, 1910, Inst. geol. México Bol. 25, p. 159, pl. 36, figs. 3–6; pl. 37, figs. 1–8; pl. 38, figs. 1, 2.
Holectypus planatus Roemer (part). CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 65. Not figures.
Holectypus transpecosensis, ADKIN, 1928, Texas Univ. Bull. 2838, p. 282.

Occurrence.—TEXAS: Sierra Blanca Mountains (type, Streeruwitz and Wyschetzki, *fide* Cragin); pass between North and South Sierra Blanca Peaks, Sierra Blanca quadrangle (USGS 1914, T. W. Stanton); 2 miles west of Kent, Culberson County (USGS 1929, T. W. Stanton); near water tank 8 miles west of Kent (USGS 1930, 1939, T. W. Stanton); 7 miles east of Kent (USGS

14250, T. W. Stanton and W. P. Popenoe); 5 miles west of Kent (USGS 1937, T. W. Stanton); 1 mile south-southeast of station at Kent (USGS 1931, 1933, T. W. Stanton); 6 miles west of Kent (USGS 1928, T. W. Stanton); south side of Rio Grande between railway bridge across the river and the Initial Monument 4 miles west of El Paso (USGS 1689, E. A. Mearns); side of high hill capped with igneous rock east of dome-shaped mesa of Cerro San Antonio (USGS 2754, R. T. Hill and G. H. Girty); west point of Castle Mountain, Upton County, on upper slope between the cap rock and the lower cliff-forming limestone 40 feet lower (USGS 13178, T. W. Stanton and W. B. Lang);

MEXICO: Cerro Muleros, above the Initial Monument, 5 or 6 kilometers northwest of Ciudad Juarez, Chihuahua (type of *H. limitis, fide* Böse). This place must be near USGS 1689.

Geologic horizon.—Washita group.

Remarks.—Holectypus transpecosensis is known only from western Texas and adjacent Mexico, where it is the only species of the genus thus far discovered. It attained a size two or three times as large as *H. planatus*, from which it is further distinguished by its proportionately much smaller periproct. Its peristome is larger than that of *H. castilloi*, and its periproct is larger and farther from the margin.

Family PYGASTERIDAE

Having only four genital plates, the right anterior plate filling the central space and extending between but not beyond the posterior oculars, which are widely separated. Ambulacral areas simple, poriferous zones continuous, not petaliferous. Peristome central, sunken, notched. Periproct large, flush, straight or oblique.

Genus ANORTHOPYGUS Cotteau, 1856

Anorthopygus COTTEAU, 1856, Soc. géol. France Bull., sér. 2, t. 13, p. 648.
Anorthopygus, COTTEAU, 1861, Paléontologie Française, Terrain crétacé, t. 7, p. 62.
Anorthopygus, COTTEAU, 1863, Congrès sci. France Mém., session 28, t. 3, p. 196.
Anorthopygus, COTTEAU AND TRIGER, 1869, Échinides du Département de la Sarthe, p. 410.
Anorthopygus, POMEL, 1883, Classification méthodique et genera des échinides, p. 75.
Pseudopileus DE LORIOL, 1901, Notes pour servir à l'étude des échinodermes, ser. 1, fasc. 9, p. 29 (*fide* Lambert and Thiéry, 1914).
Anorthopygus, LAMBERT AND THIÉRY, 1914, Nomenclature raisonnée des échinides, fasc. 4, p. 278.

Genotype, *Nucleolites orbicularis* Grateloupe, 1836, from the Cenomanian of France, by monotypy. This species has been figured by Cotteau (1861, p. 63, pl. 1019) and by Cotteau and Triger (1869, p. 177, pl. 31, figs. 1–9). It has only four genital plates. The madreporite protrudes between the posterior oculars, which are wide apart. The ambulacral poriferous zones are uniserial and continuous to the peristome, which is rather small, deeply sunken, and notched. The periproct is large, oblique, flush, and on the upper surface near the margin.

ANORTHOPYGUS TEXANUS Cooke, n. sp.
Plate 34, figures 9–12

Test subcircular, tumid, margin rounded, deeply depressed at the peristome, slightly depressed below the periproct. Apical system central; five ocular plates, four genital plates, the madreporite large and extending backward between the posterior ocular plates, which are widely separated. Ambulacral areas about half as wide as the interambulacral areas; plates very short and wide, one pair of pores to the plate; poriferous zones consisting of a single row of pore pairs, continuous to the peristome, pore pairs transverse except near the peristome, where they become diagonal; pores of a pair diverging inward, causing the pore pairs to appear wider where corroded. Peristome central, sunken, transversely oval, slightly notched, diameter about one-fourth that of the test. Periproct large, flush, subpyriform, oblique, extending above the margin. Tubercles large, perforated, in deep scrobiculi, closer together on the under surface; intermediate spaces granular.

Length, 30 mm.; width, 31 mm.; height, 17 mm.

Occurrence.—TEXAS: Castle Mountain, Upton County, slope between cap rock and cliff-forming limestone (USGS 13176, 13178, type, T. W. Stanton and W. B. Lang); 6 miles east of Kent (USGS 14251, T. W. Stanton and W. P. Popenoe); 2 miles west

of Kent (USGS 1929, T. W. Stanton); near water tank 8 miles west of Kent (USGS 1930, T. W. Stanton); Seven Mile Mesa, east of Fort Stockton (USGS 13193, T. W. Stanton and W. B. Lang); 2 miles southeast of road forks "15 miles to Garvin" (USGS 13907, N. H. Darton); east of Cerro San Antonio (USGS 2754, R. T. Hill and G. H. Girty).

Geologic horizon.—Washita group: limestone of Duck Creek and Fort Worth ages.

Remarks.—In size and shape *Anorthopygus texanus* resembles *Globator parryi* (Hall). from which it can be distinguished by its larger, transverse peristome, by its larger, oblique periproct, by the separation of its posterior ocular plates by the madreporite, and by the arrangement of its pore pairs, which are not in groups of three near the peristome. It somewhat resembles *Holectypus planatus*, but it is generally taller its bottom is rounder, and its periproct is not below the margin. Poorly preserved individuals might be mistaken for *Pedinopsis symmetrica*, which has double rows of pore pairs, which is more nearly globular, and whose periproct lies within the apical system. *Anorthopygus texanus* bears a striking resemblance to the genotype, but its periproct is more nearly marginal than is indicated by Cotteau's figures of *A. orbicularis*.

Family ECHINONEIDAE Wright, 1864

Genus PYRINA Des Moulins, 1835

Pyrina DES MOULINS, 1835, Études sur les échinides, p. 26.
Not *Pyrina* of other authors.

Genotype, *Nucleolites castanea* Brongniart, 1822, here designated. Lambert's (1908, p. 286) designation of "*P. petrocoriensis* Des Moulins" (=*Globator petrocoriensis* Agassiz, 1847) as the genotype of *Pyrina* is not acceptable under the International Code of Zoological Nomenclature because that name was a *nomen nudum* when the genus was first described. Des Moulins referred to *Pyrina* seven nominal species, of which two were *nomina nuda* and two were doubtfully assigned to *Pyrina*. The remaining three, from which the genotype must be selected, are *Galerites rotula* Brongniart, *Nucleolites depressa* Brongniart, and *Nucleolites castanea* Brongniart, all based on molds. According to Brongniart the most abundant of these species is *Nucleolites castanea*, which has been identified by Cotteau (d'Orbigny, 1853–1860), p. 474, footnote) as the species figured under the name *Echinoconus castanea* by d'Orbigny (1853–1860), p. 503, pl. 990). De Loriol (1873, p. 191, pl. 14, figs. 1–10) has also figured it.

No species of *Pyrina* have been found in the Comanche series. The synonymy is here discussed in order to rectify the nomenclature of *Globator parryi* (Hall), which was originally assigned to *Pyrina*.

Genus GLOBATOR Agassiz, 1840

Globator AGASSIZ, 1840, Catalogus systematicus ectyporum Echinodermatum, pp. 7, 16.
Globator, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 92.
Pyrina Des Moulins (part). D'ORBIGNY, 1853–1860, Paléontologie française, Terrain crétacé, t. 6, p. 462.
Globator, DESOR, 1858, Synopsis des échinides fossiles, p. 186.
Pyrina Des Moulins. DE LORIOL, 1873, Échinologie helvétique, pt. 2, p. 200.
Pyrina Des Moulins. POMEL, 1883, Classification méthodique et genera des échinides, p. 53.
Nucleopyrina POMEL, 1883, *idem*, p. 53.
Globator, POMEL, 1883, *idem*, p. 53.
Pseudopyrina LAMBERT, 1908, Assoc. française avanc. sci. Compte rendu 36me ses. (Rheims, 1907), p. 286.
Globator, LAMBERT AND THIÉRY, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 38.
Pseudopyrina, LAMBERT AND THIÉRY, 1921, *idem*, p. 329.
Pseudopyrina, ADKINS, 1928, Texas Univ. Bull. 2838, p. 283.
Pseudopyrina, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 463.

Genotype, *Globator nucleus* Agassiz, by monotypy. This species, as figured by d'Orbigny (1857, p. 489, pl. 987, figs. 1–5) has an elongated, slightly oblique peristome and a marginal pyriform periproct. The apical system is not distinctly drawn, but four genital pores are shown. As here interpreted, the genus lacks the posterior genital plate, and the two posterior ocular plates are in contact. The ambulacral pores are represented as continuing in straight lines to the periproct, whereas in other species now referred to the genus the pore pairs near the peristome are arranged in diagonal groups of three. If not due to a defect in the drawing, this difference may validate as a subgenus *Nucleopyrina* Pomel, whose geno-

type, *Pyrina cylindrica* Albin Gras (d'Orbigny, 1853–1860, p. 470, pl. 979), shows this feature.

GLOBATOR PARRYI (Hall)
Plate 34, figures 4–6

Pyrina parryi HALL in CONRAD, 1857, U. S. and Mexican Boundary Survey Rept., pt. 2, p. 144, pl. 1, figs. 1a–d.
Pyrina parryi, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 59, pl. 24, figs. 1a–k.
?Pyrina bulloides CRAGIN, 1893, Texas Geol Survey Ann. Rept. 4, pt. 2, p. 162.
Pyrina parryi, CRAGIN, 1893, *idem*, p. 162.
Pyrina inaudita BÖSE, 1910, Inst. geol. México Bol. 25, p. 162, pl. 38, figs. 3–8; pl. 39, figs. 1, 2, 4.
Pyrina clarki BÖSE, 1910, *idem*, p. 163, pl. 39, figs. 3, 5–8; pl. 40, figs. 1–3.
Pyrina parryi, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 67, figs. 1a–i.
Pseudopyrina parryi, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 269.
Pseudopyrina clarki ADKINS, 1928, Texas Univ. Bull. 2938, p. 283.
Pseudopyrina parryi, ADKINS, 1928, *idem*, p. 283.
Pseudopyrina? bulloides, ADKINS, 1928, *idem*, p. 284.
Pseudopyrina inaudita, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 463, pl. 63, figs. 5, 6.
Pseudopyrina parryi, SMISER, 1936, *idem*, p. 463, pl. 63, figs. 11–14.
Pseudopyrina clarki, SMISER, 1936, *idem*, p. 463, pl. 63, figs. 7–10.
Pyrina whitneyi IKINS 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 74 (26), pl. 6 (3), figs. 4a–c.

Occurrence.—TEXAS: Leon Springs, El Paso road (type, USNM 9854, W. H. Emory); west side of Rio Grande about 4 miles northwest of El Paso, bed 5 of section (USGS 1464, E. A. Mearns); south side of Rio Grande near El Paso, between the railway bridge and the Initial Monument (E. A. Mearns); gap between North and South Sierra Blanca Peaks, El Paso County (USGS 1914, T. W. Stanton); 2 miles west of Kent, Culberson County (USGS 1929, T. W. Stanton); near water tank 8 miles west of Kent (USGS 1930, T. W. Stanton); 1 mile southeast of station at Kent (USGS 1931, T. W. Stanton); south side of high hill capped with igneous rock east of dome-shaped mesa of Cerro San Antonio (USGS 2454, R. T. Hill and G. H. Girty); 165 to 185 feet above base of hill on south side of highway 6 miles east of Kent (USGS 14251, T. W. Stanton and W. P. Popenoe); Castle Mountain, Upton County (USGS 13176–13178, T. W. Stanton and W. B. Lang); southwest perimeter of Pilot Knob, Travis County (R. T. Hill and T. W. Vaughan); south of Taylors Creek, Travis County (R. T. Hill and T. W. Vaughan); Onion Creek near Knuckle's crossing, half a mile below Lower Lockhart crossing (R. T. Hill and T. W. Vaughan); Hog Creek near Ocee, 15 miles west of Waco (USGS 3195, J. K. Prather).

Geologic horizon.—Washita group: Georgetown limestone, chiefly Fort Worth equivalent.

Types.—USNM 9854, two cotypes.

Remarks.—*Globator parryi* is subject to considerable variation in shape. Its horizontal profile ranges from oval to circular, and many individuals are subpentagonal. The upper surface is always inflated, but some individuals are nearly as high as wide, while others are flatter. The lower surface is more or less flattened. The periproct is flush, though there is a slight depression below it. It is oval or pyriform and always erect except in deformed individuals. The peristome is suboval to irregular in shape. It is longer than wide but is generally turned slightly clockwise when seen from below.

Some of the specimens at hand are weathered in such a manner as to reveal very plainly the plates of the apical system. The two posterior ocular plates lie adjacent to each other, the posterior genital plate being absent. This condition readily distinguishes *Globator* from *Anorthopygus*, in which the posterior oculars lie farther apart and are separated by the elongated madreporite, which protrudes between them.

Each poriferous zone of *Globator parryi* consists of a single row of pore pairs, which is broken into diagonal groups of three pairs in the vicinity of the peristome.

Family CASSIDULIDAE Agassiz and Desor, 1847

Genus CLYPEOPYGUS d'Orbigny, 1856

Clypeopygus D'ORBIGNY, 1856, Paléontologie française, Terrain crétacé, t. 6, pp. 291, 418.
Clypeopygus, DESOR, 1858, Synopsis des échinides fossiles, p. 273.
Clypeopygus, WRIGHT, 1875, British fossil Echinodermata from the Cretaceous, vol. 1, p. 246.
Clypeopygus, POMEL, 1883, Classification méthodique et genera des échinides, p. 61.

Porobrissus LAMBERT, 1916, Rev. critique de paléozoologie, t. 20, p. 169.
Nucleopygus (*Porobrissus*), LAMBERT AND THIÉRY, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 347.
Clypeopygus, LAMBERT AND THIÉRY, 1921, *idem*, p. 348.

Genotype, *Clypeus paultrei* Cotteau, designated by Lambert and Thiéry (1921, p. 348), from the Neocomian of France. As figured by d'Orbigny (1856, p. 420, pl. 964), this is a large, depressed species with four genital pores and a large central madreporite. It has five similar petals, which are open at the outer ends and have circular inner pores and elongated outer pores. Its peristome is pentagonal, in front of the center, and is surrounded by a rather faint floscelle. Its periproct is oval, on the upper surface, in a deep, steep-walled sulcus, which extends nearly halfway to the apex.

Clypeopygus shows many features in common with other Cassidulidae, to which it was assigned by Desor. It is commonly referred to the Echinobrissidae, in which it was originally placed by d'Orbigny, but that name cannot be used because *Echinobrissus* Gray, 1825, is an absolute synonym of *Nucleolites* Lamarck, 1801, both having as genotype *Nucleolites scutata* Lamarck, 1816, which was the first valid specific name assigned to *Nucleolites*. Moreover, the arrangement of the apical plates in the Jurassic *Nucleolites scutata* Lamarck (Cotteau, 1872, pl. 77, fig. 5) differs from that of the Lower Cretaceous *Clypeopygus paultrei* (Cotteau).

CLYPEOPYGUS ANGUSTATUS (Clark)
Plate 31, figures 10–13

Echinobrissus angustatus CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 69, pl. 27, fig.. 2a–c.
Echinobrissus angustatus, WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 98, pl. 21, figs. 6–9; pl. 23, fig. 4.
Porobrissus angustatus, LAMBERT, 1916, Revue critique de paléozoologie, t. 20, no. 4, p. 169.
Nucleopygus (*Porobrissus*) *angustatus*, LAMBERT AND THIÉRY, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 348.
Clypeopygus angustatus, LAMBERT AND THIÉRY, 1921, *idem*, p. 348.
Porobrissus angustatus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 284.

Occurrence.—TEXAS: Shoal Creek near Austin (type); Austin (*fide* Whitney).

Geologic horizon.—Washita group: upper part of the Buda limestone (*fide* Whitney).

Type.—USNM 103,701, deposited by Johns Hopkins University (T 3009).

Remarks.—This species is represented in the National Museum by the type and one fragment. Whitney reports 27 specimens, which presumably are at the University of Texas.

Clark's figures 2a and 2b show the shape and size of the type, but figure 2c, the profile, is too flat behind. Removal of the matrix from the sulcus shows that the periproct is much larger than it is represented in Clark's figure 2a. The periproct lies in the forward part of the sulcus, where it is deeply sunken. Lambert (1916, p. 169) made this species the type of the new genus *Porobrissus* on the basis of Clark's figures. Lambert and Thiéry (1921, p. 347) reduced *Porobrissus* to a subgenus of *Nucleopygus* and on the next page transferred its genotype to *Clypeopygus* on the basis of the excellent figures by Whitney.

Family HEMIASTERIDAE, H. L. Clark, 1917
Genus HEMIASTER Desor, 1847

Hemiaster DESOR in AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 122.
Hemiaster, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 477.
Hemiaster, COOKE, 1942, *idem*, vol. 16, no. 1, p. 43. Gives additional synonymy.

Genotype, *Spatangus bufo* Brongniart, 1822, from the Cenomanian of France, designated by Pomel (1883, p. 42). This species has been figured by Agassiz and Desor (1847, pl. 6, fig. 7) and by d'Orbigny (1853, pl. 873). D'Orbigny figured a specimen about 30 mm. long and wide and three-quarters as high. The highest point is near the posterior end, which is steeply truncated. Characteristic generic features appear to include nearly straight sunken petals surrounded by a fasciole, which is not sinuous; paired petals having short slot-shaped pores rather far apart; odd ambulacrum having diagonal pairs of oval pores set at an angle to each other and separated by a granule; peristome bordered by a narrow continuous raised rim or lip, transversely oval or reniform; periproct oval, higher than wide, set high on the truncated end.

KEY TO THE COMANCHE HEMIASTERS

1. Petals extending less than nine-tenths of the way to the margin; periproct not overhanging.
   2. Posterior petals nearly as long as the anterior pair, which extend about four-fifths of the way to the margin ..... *Hemiaster comanchei.*
   2. Posterior petals shorter than the anterior pair.
      3. Posterior petals about three-fourths as long as the anterior pair.
         4. Petals deeply depressed; test strongly rostrate behind; posterior truncation sloping backward ..... *Hemiaster calvini.*
         4. Petals shallow; test not strongly rostrate behind; truncation nearly vertical ..... *Hemiaster whitei.*
      3. Posterior petals little more than half as long as the anterior pair; petals deep ..... *Hemiaster cranium.*
1. Petals longer, extending about nine-tenths of the way to the margin; fasciole inconspicuous or wanting ..... Subgenus *Macraster.*
   2. Periproct conspicuously overhanging.
      3. Horizontal profile equilaterally subtriangular; petals moderately depressed ..... *Hemiaster elegans elegans.*
      3. Horizontal profile ovate; petals nearly flush ..... *Hemiaster elegans wenoensis.*
   2. Periproct not conspicuously overhanging.
      3. Test much longer than wide; greatest width at the anterior third; periproct not visible from above ..... *Hemiaster elegans subobesus.*
      3. Test not much longer than wide; greatest width in front of the anterior third; periproct generally visible from above ..... *Hemiaster elegans washitae.*

HEMIASTER COMANCHEI Clark

Plate 32, figures 6, 7

Toxaster elegans (Shumard). CONRAD, 1857, U. S. and Mexico Boundary Survey Rept., vol. 1, pt. 2, p. 146, pl. 21, figs. 1a–e.

?*Epiaster cuevasensis* DE LORIOL, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, p. 54, pl. 4 (7), figs. 11, 11b.

Hemiaster comanchei CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 90, pl. 45, figs. 2a–d.

Hemiaster whitei Clark (part). CLARK, 1915, *idem*, pl. 45, figs. 2a–f.

Hemiaster (*Mecaster*) *comanchei*, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 502.

Hemiaster commanchei, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 273.

Hemiaster (*Mecaster*) *comanchei*, ADKINS, 1928, Texas Univ. Bull. 2838, p. 299.

Macraster solitariensis SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 472, pl. 65, figs. 13, 15, 16, 18, 19.

Not *Palhemiaster comanchei* (Clark). SMISER, 1936, *idem*, p. 475, pl. 66, figs. 5–8, 10 (=*Hemiaster whitei* (Clark)).

Occurrence.—TEXAS: Santa Monica Springs, bed of Colorado River about 10 miles west of Austin (type USNM 103893, R. T. Hill; USNM 32094); South Llano River (USNM 9609); bank of Cibolo River about 2½ miles west of Bulverde road crossing, northern Bexar County (USGS 10200, O. B. Hopkins); west side of The Solitario and near Solitario Peak (USGS 14192, T. W. Stanton and W. P. Popenoe); Solitario Rim (Texas Bureau Economic Geology, type of *M. solitariensis*); north side of Persimmon Gap, Santiago Mountains, no. 7 of section, Bone Springs quadrangle (USGS 14193, T. W. Stanton and W. P. Popenoe); Eagle Springs (USNM 9856, figured by Conrad, 1857); one-fourth mile west of Jacobs Well, near Wimberly, Hays County (USGS, A. N. Sayre); road to D'Hanis 2½ miles southeast of Utopia, Uvalde County (USGS 13635, N. H. Darton and T. W. Stanton); east bank of Mayfield Canyon near its mouth, about 3 miles east of Indian Hot Springs (USGS 18359, J. B. Reeside, Jr., and Ralph Imlay); 2 miles north of Guadalupe River at Cranes Mill and 150 feet above it (USGS 11866, T. W. Stanton); Cranes Mill-New Braunfels road, about 3 miles south of Guadalupe River, 222½ feet above bridge, Comal County (USGS 18384, Ralph Imlay).

Geologic horizon.—Trinity group: Glen Rose limestone.

Type.—USNM 103893, deposited by Johns Hopkins University (T 3012), from Santa Monica Springs.

Remarks.—The type of *Hemiaster comanchei* is about the same size as the type of *H. elegans washitae*, from which it differs in its shorter anterior paired petals, its smaller and more strongly inflected anterior pore pairs, its larger periproct, which is farther forward, and its wider posterior end, which slopes less steeply. The petals of *H. comanchei* are shallower than those of *H. calvini*, and the posterior pair are longer. The petals

are deeper than those of *H. whitei*, whose posterior end is more nearly erect.

Hemiaster comanchei should be compared with *Epiaster cuevasensis* de Loriol, whose horizon I do not know, and with *Epiaster electus* Cragin (1893, p. 152), which apparently also comes from the Glen Rose limestone. Both of these specific names are older than *H. comanchei*.

H. comanchei varies greatly in shape; most specimens are much shorter than the type. As many specimens referred to it are crushed, distorted, or otherwise imperfect, more than one species may be represented in the material at hand.

HEMIASTER? ELECTUS (Cragin)

Epiaster electus CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 152.

Occurrence.—TEXAS: Bed 9 of Taff's Sandy Creek section, Travis County (Texas Geol. Survey, Ann. Rept. 3, p. 299).

Geologic horizon.—Trinity group: Glen Rose limestone.

Type.—Probably University of Texas, Austin.

Remarks.—This species, which I have not seen, should be compared with *Hemiaster comanchei* Clark. Clark (1915) put it in the synonymy of *Hemiaster elegans*, which occupies a much higher stratigraphic level.

HEMIASTER WHITEI (Clark)
Plate 32, figures 16, 17

Epiaster whitei CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 77.
Epiaster whitei, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 82, pl. 43, figs. 2a–d; pl. 44, figs. 1a–g.
Epiaster whitei, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 154.
Epiaster elegans v. *praenuntius* CRAGIN, 1893, *idem*, p. 152.
Hemiaster whitei (part), CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 89. pl. 43, figs. 2a–c; pl. 44, figs. 1a–h. Not pl. 45, figs. 1a–c (type of *Macraster washitae* Lambert) not pl. 45, figs. 2a–f (*H. comanchei* Clark).
Hemiaster whitei, ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 53.
Hemiaster sp. *b*, ADKINS AND WINTON, 1920, *idem*, p. 53, pl. 8, figs. 7–9.
Pliotoxaster whitei, LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., Année 1919, p. 128.
?Epiaster bosei LAMBERT, 1924, in LAMBERT AND THIÉRY, Nomenclature raisonnée des échinides, fasc. 6, p. 478, pl. 12, figs. 8, 9.
Hemiaster whitei, WINTON, 1925, Texas Univ. Bull. 2544, p. 50, pl. 12, fig. 10.
Epiaster whitei, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 272.
Epiaster whitei, ADKINS, 1928, Texas Univ. Bull. 2838, p. 297.
?Epiaster washitae (Lambert). ADKINS, 1930, *idem*, Bull. 3001, p. 119.
?Epiaster whitei, LAMBERT, 1935, Soc. géol. France Bull., sér. 5, t. 5, p. 370.
Not *Pliotoxaster whitei*, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p 464, pl. 65, figs. 9, 12, 14, 17, 20. (*Hemiaster washitae* (Lambert)).

Occurrence.—TEXAS: Lake Worth dam near Fort Worth, bed 8 of Winton's section (USGS 11755, T. W. Stanton); north side of west fork of Trinity River just east of Lake Worth dam (USGS 11758, 11760, T. W. Stanton); road cut east of creek east of Westover, northwest of Arlington Heights, Fort Worth (USGS 18553, Ralph Imlay); Benbrook, 8 miles west of Fort Worth, around depot (USGS 1577, Frank Burns); Nolands River 1 mile west of Blum (USGS 11823, T. W. Stanton); bluff on Brazos River about 4 miles northwest of Whitney, Hill County (USGS 11842, T. W. Stanton).

Geologic horizon.—Fredericksburg group: Goodland limestone.

EXPLANATION OF PLATE 33

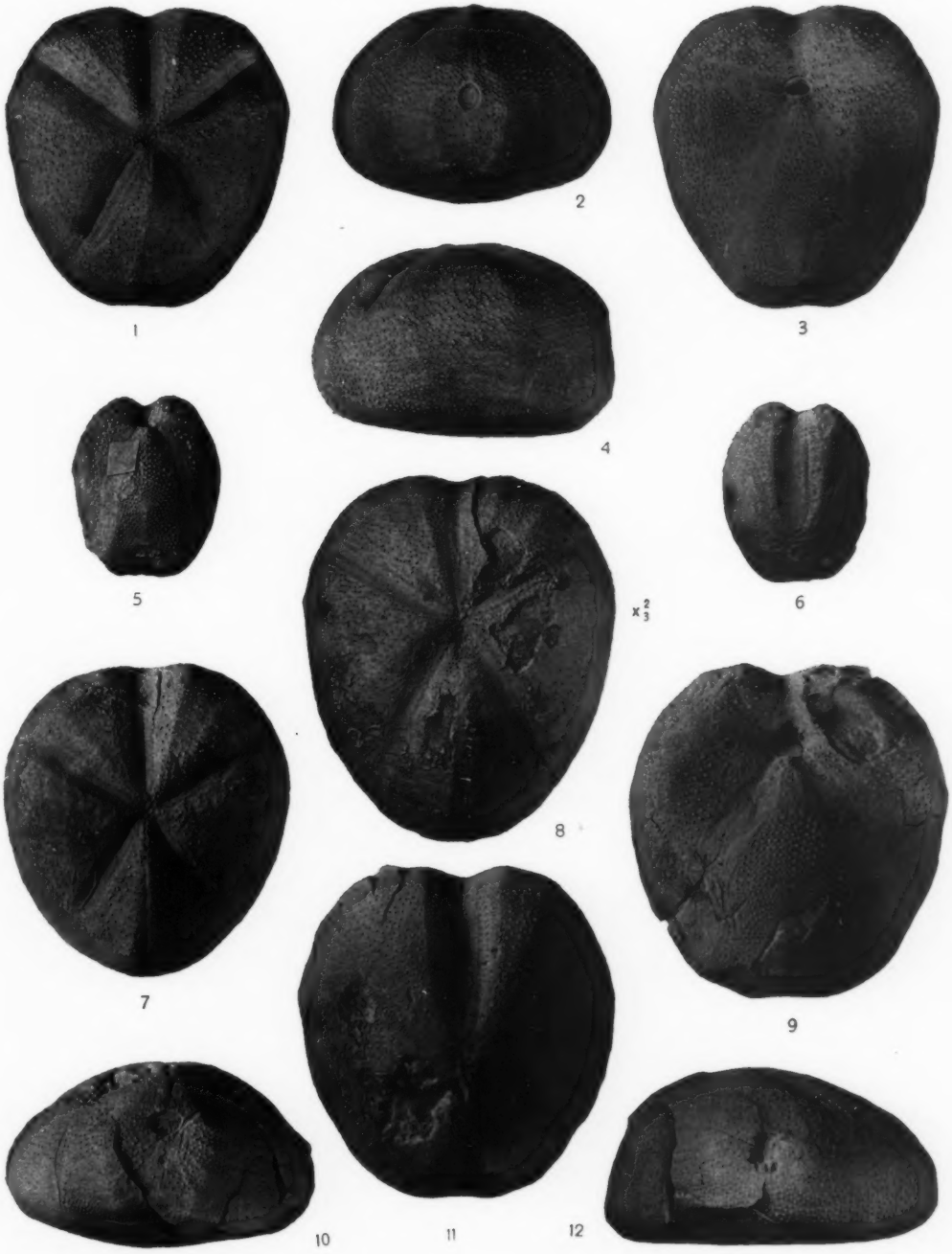
FIGS. *1–4—Hemiaster* (*Macraster*) *elegans washitae* (Lambert). Top, posterior end, bottom, and left side of holotype, USNM 31202, ×1. Duck Creek, near Denison, Texas; Washita group. (p. 229)

5, 6—Enallaster longisulcus Adkins and Winton. Bottom and top of holotype, ×1. Cedar Creek branch of Nolands River 2 miles southeast of Blum, Johnson County, Texas; Washita group, upper part of Fort Worth limestone. (p. 232)

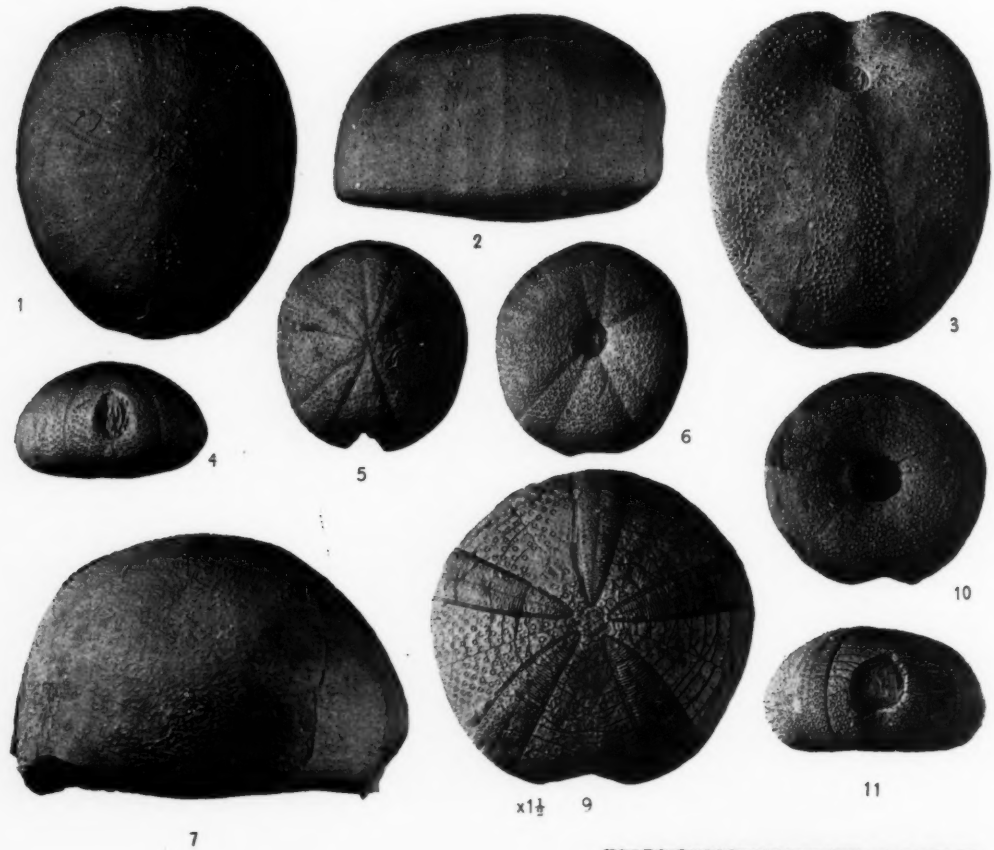
7—Hemiaster (*Macraster*) *elegans wenoensis* (Adkins). Top of USNM 103892, ×1. Renfro collection Ft. W 26, near Forth Worth, Texas: Washita group: Weno limestone. (p. 228)

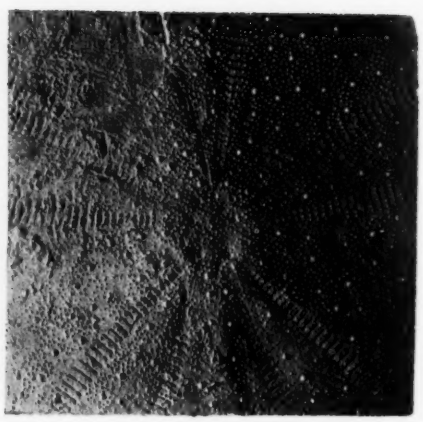
8—Hemiaster (*Macraster*) *elegans subobesus* (Adkins). Top of USNM 103883, ×$\frac{3}{4}$. USGS 18541, corner of NE. 33d Street and N. Grove, just east of railroad, Diamond Hill, Fort Worth, Texas; Washita group: Duck Creek limestone. (p. 229)

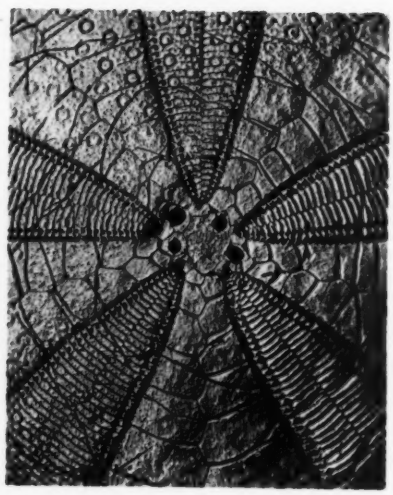
9–12—Enallaster texanus (Roemer). Bottom, posterior end, top, and left side of USNM 12237 (type of *E. obliquatus* Clark), ×1. Near Austin, Texas; Trinity group. (p. 231)



Cooke, Comanche Echinoids







Cooke, Comanche Echinoids

Type.—USNM 9732. This specimen was received from the Army Medical Museum without locality. Its present label credits it to Duck Creek, near Denison—evidently a mistake, for the species is unknown there, and the specimen is darker than others from Denison.

Remarks.—The most conspicuous difference between *Hemiaster whitei* and the young of *H. elegans washitae*, with which it is often confused, lies in the shorter petals of *H. whitei*, particularly the posterior pair. The inner rows of pores in the odd petal are diagonal in *H. whitei*, whereas they are usually nearly transverse in *H. washitae*. The pores are separated by granules in both species, though the granules are commonly worn off. Both *H. whitei* and *H. washitae* have an obscure, diffuse peripetalous fasciole which commonly is not entirely free from tubercles. The fasciole is somewhat more conspicuous in *H. comanchei*, a higher species, whose posterior truncation is not so nearly vertical, and whose periproct is more plainly visible from above.

Epiaster bosei, whose type came from Benbrook, may be a young *Hemiaster whitei*, though its posterior petals, as figured by Lambert, are more widely diverging.

HEMIASTER CALVINI Clark
Plate 32, figure 5

Hemiaster calvini CLARK, 1893, Johns Hopkins Univ. Circ., vol. 12, no. 103, p. 52. *Nomen nudum.*

Hemiaster calvini CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 90, pl. 49, figs. 2a–i.

?Epiaster hemiasterinus CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 153.

Hemiaster calvini, BÖSE, 1910, Inst. geol. México Bol. 25, p. 175, pl. 43, figs. 3–5; pl. 44, figs. 1–8; pl. 45, figs. 1–3, 5.

Hemiaster calvini, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 91, pl. 47, figs. 2a–i.

Hemiaster calvini, WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 102, pl. 22, figs. 4–7; pl. 23, figs. 1–3.

Hemiaster calvini, ADKINS, 1920, Texas Univ. Bull. 1856, p. 114, pl. 5, figs. 1, 2, 4; pl. 6, fig. 3; pl. 8, fig. 6.

Hemiaster calvini, ADKINS AND WINTON, 1920, *idem*, Bull. 1945, p. 54, pl. 8, figs. 1. 2.

Epiaster calvini, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 272.

Hemiaster calvini, ADKINS, 1928, Texas Univ. Bull. 2838, p. 298.

Hemiaster calvini, SMISER, 1926, Jour. Paleontology, vol. 10, no. 6, p. 478, pl. 66, figs. 9, 11–13; pl. 67, fig. 8.

Not *Hemiaster calvini*, JONES, 1928, Geol. Soc. America Bull., vol. 49, p. 135, pl. 13, figs. 1–20.

Occurrence.—TEXAS: 4 miles northeast of Roanoke (USNM); railroad cut on southeast edge of Denison (USGS 1551, R. T. Hill, T. W. Stanton, and Frank Burns); 2 miles north of Pottsboro (USGS 1490, R. T. Hill and T. W. Stanton); Grayson Bluff, 5.2 miles northeast of Roanoke, over Denton Creek (USGS 18526, Ralph Imlay); 0.5 mile east of Burleson (USGS 19685, Renfro collection); Jennings Road 1½ miles north of Meadowbrook Drive, Handley (USGS 19684, Renfro collection); mouth of Shoal Creek near Austin (USNM 12241, type); yellow beds one-eighth mile south of Dryden (USGS 14304, N. H. Darton); 5 miles southeast of Dryden (USGS 14315, N. H. Darton); east of Reed Plateau, station 22, east half of Terlingua sheet, Brewster County (USGS 16851, C. H. Coldwell); road pit on Kerrville-Rock Springs highway 3.1 miles east, also 1½ miles south of Edwards County line, in northwestern Real County (USGS 16210, W. H. Curry, Jr.); north of W. I. Babb ranch, southwest of Zona (USGS 13909, N. H. Darton); Rio

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EXPLANATION OF PLATE 34

FIGS. *1–3*—*Holaster laevis* (Brongniart). Top, left side, and bottom of USNM 103884, ×1. USGS 9690, in Oklahoma 5½ miles north of Denison, Texas; Washita group. (p. 234)

4–6—*Globator parryi* (Hall). Posterior end, top and bottom of USNM 103875, ×1. South side of Rio Grande near El Paso, Texas, between the railroad bridge and the Initial Monument; Washita group. (p. 221)

7, 8—*Pseudananchys completa* (Cragin). *7*, Left side, ×1; *8*, apical region, ×3; of USNM 103880. USGS 18527, bed of creek 1½ miles northeast of Argyle, 7½ miles southwest of Denton, Texas; Washita group: Grayson marl. (p. 233)

9–12—*Anorthopygus texanus* Cooke, n. sp. *9–11*, Top, ×1½, bottom, ×1, and posterior end, ×1, of holotype, USNM 103881; *12*, apical region of paratype USNM 103882, ×3. USGS 13178, Castle Mountain, Upton County, Texas; Washita group. (p. 219)

Grande above El Paso, near Initial Monument (USGS 1943, 1944, T. W. Stanton); Rio Grande near Del Rio (USGS 13976, W. G. Kane); Val Verde County on road to Sanderson, 32 miles west of Del Rio (USGS 18393, Ralph Imlay).

Geologic horizon.—Washita group: Buda limestone, Grayson marl, and upper part of Georgetown limestone; Adkins reports it as low as the Weno limestone.

Types.—USNM 12241, two cotypes; one, partly corroded, the other broken on upper right side.

Remarks.—*Hemiaster calvini* is easily distinguished from other Comanche Hemiasters by its deeply excavated petals and its high, arched posterior area. Its posterior truncation is larger and more conspicuous. It might be confused with *H. texanus* Roemer (1852), an Upper Cretaceous species, but Roemer's figures are much more strongly cordate and show more widely diverging posterior petals. Jones' (1928) specimens from members 2 and 3 of the Indidura formation in Coahuila, Mexico, though closely resembling *H. calvini*, probably are not that species. They have longer, broader petals and probably a more conspicuous fasciole, though the state of preservation does not permit assurance regarding that feature.

HEMIASTER CRANIUM Cooke, n. sp.
Plate 32, figures 1–4

Test subglobular, flattened below, truncated behind, highest point slightly behind the center. Upper surface inflated, slightly depressed in front, somewhat arched above the periproct, margins evenly rounded. Petals short, in moderately deep, well-defined depressions; pores of odd petal nearly circular, separated by a granule, pairs diagonal; anterolateral petals extending little more than halfway to the margin, pores elongated, open at outer ends, closed at inner ends, nearly straight, nearly at right angles to each other; posterolateral petals about half as long as the anterolaterals, slightly curved backward, open at the outer ends, pores elongated, number of pores increasing with size. Four genital pores forming an equilateral trapezoid of height nearly equal to the mean width; madreporite to the right of the center of the trapezoid. Peripetalous fasciole wide, poorly defined. Lower surface gently rounded, outline truncated-ovate. Peristome one-third the length from the front, large, subreniform, encircled by a raised rim, strongly labiate behind. Back end truncated at an angle of about 65° from the horizontal, somewhat depressed longitudinally. Periproct near the top, plainly visible from above, oval, higher than wide, smaller than the peristome. Tubercles and granules covering most of the surface, including the fasciole.

Length of holotype, 31 mm.; width, 28 mm.; height, 20 mm. Largest paratype 36 mm. long, 33 mm. wide, 24 mm. high.

Occurrence.—TEXAS: Small washes and creek banks north of the 3000 block of Young Avenue, Fort Worth (USGS 19690, type, Renfro collection); 1½ miles northwest of the city fire hall at the intersection of Meadowbrook Drive, Oakland Boulevard, and Eiderville Road, Fort Worth (USGS 19691, Renfro collection); east end of White Lake dam, about 200 feet east of Oakland Boulevard, 1.4 miles north of the intersection of Meadowbrook Drive and Oakland Boulevard, Fort Worth (USGS 19692, Renfro collection); east of Cobb Park Road at the old Cobb brick plant diggings 1.6 miles south of Rosedale Street, Fort Worth (USGS 19693, Renfro collection); Sycamore Creek at the I. & G. N. Ry. crossing about 4 miles southeast of Fort Worth (USGS 19695, Renfro collection); near the Haslet road 2.35 miles west of the railroad station at Roanoke (USGS 19698, Renfro Collection); 0.3 mile due west of the intersection of highways 121 and 184, northeast of Birdville (USGS 19703, Renfro collection); north bank of Mustang Creek on road from Rio Vista to Blum (USGS 11826, T. W. Stanton).

Geologic horizon.—Washita group: Weno limestone.

Type.—USNM 103891.

Remarks.—*Hemiaster cranium* differs from other Comanche Hemiasters in its much shorter petals. In general appearance it resembles *H. bexari* Clark (1915), but its petals are shorter, its anterior petal is narrower, its apical system is farther forward, its genital pores are closer together transversely, and its posterior end slopes less steeply. Its aspect suggests certain European Micrasters, but it lacks the subanal

fasciole, and the pores of its paired petals are slot-shaped, not circular.

The posterior part of the holotype is eroded, causing the test to appear less rostrate behind than is normal for the species.

Subgenus MACRASTER Roemer, 1888

Macraster ROEMER, 1888, Neues Jahrb., Band 1, p. 190.
Macraster, LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., Année 1919, p. 134.
Macraster, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 472.
Macraster, ADKINS, 1928, Texas Univ. Bull. 2838, p. 294.
Macraster, ADKINS, 1930, *idem*, Bull. 3001, p. 102.
Macraster, SMISER, 1936, Jour. Paleontology, vol. 10. no. 6, p. 470.

Type species, *Macraster texanus* Roemer = *Hemiaster elegans* Shumard, by monotypy.

Macraster differs from *Hemiaster, s.s.*, in the character of its peripetalous fasciole, which in *Hemiaster* may be narrow and well defined, whereas in *Macraster* it is wide and diffuse, obscure, commonly not bare of tubercles, and in many individuals not discernible. The petals of *Macraster* are longer than those of *Hemiaster, s.s.*, and the longitudinal profile is more symmetrical—not higher behind as in *H. bufo*. The peristome is more plainly pentagonal but is bordered by a similar raised rim. The petals of *Macraster* are not as deep as those of *Hemiaster, s.s.*, and the interambulacral areas are flatter.

Authentic specimens of *Micraster trigonalis* Desor, the genotype of *Epiaster* d'Orbigny, 1853, have not been available for comparison, but d'Orbigny's (1853, p. 189, pl. 855) description and figures of it indicate that it lacks all trace of fasciole, that its peristome lacks the raised rim and is more distinctly labiate, and that its paired petals are flush. The granule between the pores of the odd ambulacrum may be wanting in *Epiaster*, but in other respects the pores of *Epiaster*, *Hemiaster, s.s.*, and *Macraster* seem to be similar.

HEMIASTER (MACRASTER) ELEGANS Shumard

Hemiaster elegans SHUMARD, 1853, Natural history of the Red River of Louisiana, Appendix E, p. 210.
Hemiaster elegans, SHUMARD, 1854, Marcy's Exploration of the Red River of Louisiana, Appendix E, p. 184, pl. 2, figs. 4a–c.
Toxaster elegans, GABB, 1859, Catalogue of the invertebrate fossils of the Cretaceous, p. 19.
Macraster texanus ROEMER, 1888, Neues Jahrb., Band 1, p. 195, pl. 6. Not *Hemiaster texanus* Roemer, 1852, an Upper Cretaceous species.
Epiaster elegans, CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 77.
Epiaster elegans, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 80, pl. 41, figs. 1a–b; pl. 42, figs. 1a–b; pl. 43, figs. 1a–e.
Epiaster elegans, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 152.
Epiaster elegans, HILL, 1901, U. S. Geol. Survey Ann. Rept. 21, pt. 7, pl. 37, fig. 4.
Epiaster aguilerae BÖSE, 1910, Inst. geol. México Bol. 25, p. 173, pl. 47, figs. 2–4, 6, 7; pl. 48, figs. 1, 2, 4.
Hemiaster elegans, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 88, pl. 41, figs. 1a–c; pl. 42, figs. 1a–h (=*H. elegans wenoensis* (Adkins)) type of *Macraster nodopyga* Lambert; pl. 43, figs. 1a–f.
Epiaster aguilerae, ADKINS, 1920, Texas Univ. Bull. 1856, p. 109, pl. 5, fig. 5; pl. 8, fig. 7.
Hemiaster elegans, ADKINS AND WINTON, 1920, *idem*, Bull. 1945, p. 53, pl. 8, figs. 3, 4.
Hemiaster elegans, WINTON, 1925, *idem*, Bull. 2544, p. 55, pl. 13, fig. 4.
Macraster texanus, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 271.
Macraster elegans, LAMBERT, 1927, *idem*, p. 272.
Macraster elegans, ADKINS, 1928, Texas Univ. Bull. 2838, p. 295, pl. 14, fig. 4.
Macraster texanus, ADKINS, 1928, *idem*, p. 296.
Macraster aguilerae, ADKINS, 1928, *idem*, p. 296.
Macraster elegans, ADKINS, 1930, *idem*, Bull. 3001, p. 111.
Macraster pseudoelegans ADKINS, 1930, *idem*, p. 108, pl. 10, figs. 1, 5; pl. 11, fig. 4.
Macraster texanus, ADKINS, 1930, *idem*, p. 113.
Macraster aguilerae, ADKINS, 1930, *idem*, p. 115.
Macraster obesus ADKINS, 1930, *idem*, p. 116, pl. 10, figs. 2–4; pl. 11, fig. 6.
?Macraster roberti ovatus SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 472, pl. 64, figs. 11–14.
Macraster pseudoelegans, SMISER, 1936, *idem*, p. 473, pl. 67, fig. 2.

Occurrence.—OKLAHOMA: One-quarter mile northeast of M.K.&T. RR. bridge 5⅓ miles north of Denison, Texas (USGS 9689, L. W. Stephenson; 11724, T. W. Stanton).

TEXAS: Frisco Railway 2½ miles north of Denison (USGS 18559, Ralph Imlay); Hickory Creek at Denton-Decatur highway about 1½ miles southeast of Krum, Denton County (USGS 18517, Ralph Imlay); 1 mile south of Krum and 0.4 mile west of overpass on Decatur-Denton highway (USGS 18520, Ralph Imlay); creek 20 yards

southeast of Frisco Railway about 8 miles southwest of center of Fort Worth (USGS 11744, T. W. Stanton and Gayle Scott); north side of west fork of Trinity River half a mile east of Lake Worth dam (USGS 11757, T. W. Stanton); west side of Leon River 1 mile northeast of Belton (USGS 11843, T. W. Stanton); I. Kleberger's crossing on North Bosque, 15 miles northwest of Waco (USGS 3261, J. K. Prather); 1 mile north of Georgetown (USGS 11864, T. W. Stanton); creek crossing half a mile east of Georgetown (USGS 18383, Ralph Imlay); south slope of Mount Bonnel, about 3 miles northwest of the Capital at Austin (USGS 7576, L. W. Stephenson); 3 miles west of Austin, one-sixth mile west, also one-sixth mile south of Bee Cave Road (A. N. Sayre); Seven Mile Mesa, Fort Stockton quadrangle, east of Fort Stockton (USGS 13194, T. W. Stanton and W. B. Lang); half a mile north of Leon Springs, 9 miles west of Fort Stockton (USGS 14207, T. W. Stanton); University Mesa, about 15 miles northeast of Fort Stockton (USGS 14212, T. W. Stanton and W. P. Popenoe); Devils River just below mouth of Rough Canyon, 20 miles northwest of Del Rio (USGS 4091, T. W. Stanton); southeast side of Sierra Blanca Peak (USGS 14682, N. H. Darton); 7 miles east of Kent (USGS 14250, T. W. Stanton and W. P. Popenoe); 3 miles west of Boracho and 13 miles west of Kent (USGS 14258, T. W. Stanton and W. P. Popenoe).

Geologic horizon.—Washita group: Georgetown limestone and equivalents, the typical form is most common in the Fort Worth limestone.

Type.—From Fort Washita, Oklahoma. Apparently lost (see Adkins, 1930, p. 112). The type of *Macraster pseudoelegans*, the property of the Bureau of Economic Geology and Technology, Austin, Texas, is on temporary deposit at the U. S. National Museum.

Remarks.—In spite of the many names that have been applied to it, *Hemiaster elegans* is no more variable than is to be expected of any prolific species. The specimen regarded as typical by Adkins and Winton (1920) is somewhat smaller than the type of *Macraster obesus* Adkins (1930), and the other differences between them appear not to be specific. Both specimens are a little higher than *Epiaster aguilerae* Böse, which is likewise put in the synonymy. All three are large, nearly equilateral, and have an overhanging periproct. The apical system is slightly in front of the center.

The typical form of the species is most common in the Fort Worth limestone but apparently extends downward into the Duck Creek limestone.

Three subspecies are admitted—*wenoensis*, *subobesus*, and *washitae*. *H. elegans wenoensis* is much less angular and is smoother than typical *H. elegans* and has shallower petals. Its periproct, also, is overhanging. It is most common in the Weno clay. *H. elegans washitae*, which occurs abundantly in the Duck Creek formation, has straighter sides. It is somewhat longer and more conspicuously truncate behind, and its truncation stands nearly vertical or slopes so that the periproct is visible from above. *H. elegans subobesus* is still more elongated, but in other features it more closely resembles the typical form.

HEMIASTER ELEGANS WENOENSIS
(Adkins)
Plate 33, figure 7

Hemiaster elegans Shumard (part). CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 88, pl. 42, figs. 1a–h. Type of *Macraster nodopyga* Lambert.
Epiaster wenoensis ADKINS, 1920, Texas Univ. Bull. 1856, p. 105, pl. 6, fig. 6.
Macraster nodopyga LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., Année 1919, p. 134.
Macraster wenoensis, LAMBERT, 1927, Soc. géol. France Bull., ser. 4, t. 26, p. 272.
Macraster nodopyga, LAMBERT, 1927, *idem*, p. 272.
Macraster wenoensis, ADKINS, 1928, Texas Univ. Bull. 2838, p. 297.
Macraster nodopyga, ADKINS, 1928, *idem*, p. 296, pl. 8, fig. 4.
Macraster nodopyga, ADKINS, 1930, *idem*, Bull. 3001, p. 110.
Macraster wenoensis, ADKINS, 1930, *idem*, p. 116.

Occurrence.—TEXAS: 3 miles southeast of Fort Worth (type, Texas Bureau of Economic Geology 618, W. S. Adkins); Big Fossil Creek at eastern end of Birdville at north side of Fort Worth (USGS 18534, Ralph Imlay); crossing of Rock Creek 14.5 miles south-southwest of Worth cotton mill, Fort Worth (USGS 18535, Ralph Imlay); Johnson Branch, south side of Cleburne-Godley road, northwest of Cleburne, Johnson County (USGS 18576,

Ralph Imlay); 1¼ miles west of Riovista, Johnson County (USGS 11827, T. W. Stanton).

Geologic horizon.—Washita group: Weno limestone and Pawpaw formation.

Type.—Bureau of Economic Geology and Technology, Austin, Tex., locality 618, on temporary deposit at the United States National Museum.

Remarks.—This subspecies is more evenly rounded, less angular, and has shallower petals than typical *Hemiaster elegans* and its other subspecies. It is slightly longer than typical *H. elegans* and shorter than *H. elegans subobesus*. It is further distinguished from *H. elegans washitae* by its overhanging periproct.

HEMIASTER ELEGANS SUBOBESUS (Adkins)
Plate 33, figure 8

Epiaster subobesus ADKINS, 1920, Texas Univ. Bull. 1856, p. 110, pl. 11, fig. 3.
Macraster subobesus, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 272.
Macraster subobesus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 296, pl. 19, fig. 4.
Macraster subobesus, ADKINS, 1930, *idem*, Bull. 3001, p. 110.
Macraster kentensis ADKINS, 1930, *idem*, p. 106, pl. 11, figs. 1–3, 5.
Macraster subobesus kentensis, SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 474, pl. 67, fig. 7.

Occurrence.—TEXAS: Escarpment just south of the Texas & Pacific Railroad, Kent, Culberson County (Texas Bureau Economic Geology 112, type of *Macraster kentensis*); corner of NE. 33d Street and N. Grove, just east of railroad, Diamond Hill, Fort Worth (USGS 18541, Ralph Imlay); 1 mile southeast of Riovista (type, *fide* Adkins).

Geologic horizon.—Washita group: Duck Creek limestone.

Type.—Texas Bureau of Economic Geology, Austin, on temporary deposit at the United States National Museum. *H. elegans subobesus* is very close to *H. elegans washitae*, but it is commonly larger, somewhat more elongated, its greatest width is farther back, and its posterior truncation is a little narrower and generally overhanging, whereas that of *H. elegans washitae*, when not erect, slopes so that the periproct is visible from above. The subspecies *H. elegans subobesus* is considerably more elongated than the typical *H. elegans* but is very similar to it in other respects.

HEMIASTER ELEGANS WASHITAE (Lambert)
Plate 33, figures 1–4

Hemiaster whitei (Clark) (part). CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 89, pl. 45, figs. 1a–d. Type of *Macraster washitae* Lambert.
Macraster washitae LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., Année 1919, p. 134.
?Palhemiaster ex. cf. *comanchei* (Clark). SCOTT, 1926, Études strat. et paléont. sur les terrains crétacé du Texas, p. 155, pl. 2, figs. 3[1–3].
Macraster washitae, LAMBERT, 1927, Soc. géol. France Bull., sér. 3, t. 26, p. 272.
Macraster washitae, ADKINS, 1928, Texas Univ. Bull. 2838, p. 296.
Pliotoxaster inflatus SMISER, 1936, Jour. Paleontology, vol. 10, no. 6, p. 465, pl. 63, figs. 1, 4, 15, 23–25.
Pliotoxaster whitei (White). SMISER, 1936, *idem*, p. 464, pl. 65, figs. 9, 12, 14, 17, 20.
Macraster aguilerae Böse. SMISER, 1936, *idem*, p. 474, p. 67, fig. 7.
Macraster washitae, SMISER, 1936, *idem*, p. 471, pl. 67, figs. 3, 5, 6, 9. 10.
Macraster denisonensis SMISER, 1936, *idem*, p. 471, pl. 66, figs. 1–4.
Macraster texanus Roemer. SMISER, 1936, *idem*, p. 473, pl. 67, fig. 1.

Occurrence.—TEXAS: Duck Creek near Denison (USGS 71, type, R. T. Hill); 4 miles north of Denison (USGS 1550, R. T. Hill and T. W. Stanton); 3 miles north of Denison (USGS 1566, Frank Burns); east of Frisco Railroad 2.9 miles north of Denison (USGS 6982, L. W. Stephenson); dam on Red River north of Denison (USGS 18562, Ralph Imlay); Thompson's Ferry, Red River, near Preston (USGS 1500, R. T. Hill and T. W. Stanton); 5 miles north of Denton (Texas Bureau of Economic Geology 286, type of *Macraster denisonensis* Smiser); Big Fossil Creek, east side of road to Blue Mound and Haslet, about 4 miles south of Blue Mound and about 9 miles north of courthouse at Fort Worth (USGS 18540, Ralph Imlay); Oakhurst Road at intersection with Smilax Road, Fort Worth (USGS 18542, Ralph Imlay); University Mesa, Fort Stockton (Texas Bureau of Economic Geology 1026, type of *Pliotoxaster inflatus* Smiser).

Geologic horizon.—Washita group: Duck Creek limestone.

Type.—USNM 31202.

Remarks.—*Hemiaster elegans washitae* is more elongated than typical *H. elegans* and less elongated than *H. elegans subobesus*. Its

sides are straighter. Its greatest width is far forward, as in the typical form, farther than in *H. elegans subobesus*. Its posterior truncation is wider than in either of them and stands either vertical or slopes downward and backward, never overhanging, as is customary in typical *H. elegans* and in *H. elegans subobesus*, with which it appears to intergrade.

The type was figured by Clark (1915) under the name *Hemiaster whitei* Clark, which has proportionately shorter petals and whose anterior paired petals diverge at a smaller angle and are slightly curved. The peristome of *H. whitei* is somewhat farther forward.

The inner and the outer pores of the odd petal of the type form a very obtuse angle with one another, more obtuse than that of the majority of other specimens from the same locality. This difference in the angularity of the pores seems not to be of specific importance, though it may represent a sexual characteristic. The inner and the outer pores of the paired petals lie nearly in straight lines except at each end of the petals, where they are slightly inclined.

Smiser's specimen of *Pliotoxaster inflatus* Smiser from Munson Park, Denison, Texas, is somewhat larger and more inflated than the type of *H. washitae*, with which it is here united, and its posterior paired petals are slightly shorter, even though they contain a few more pairs of pores. The posterior end, though crushed, appears not to differ materially from that of *H. elegans washitae*. The pore pairs of the odd petal are like those of the less obtuse kind of *H. elegans washitae*.

Genus ENALLASTER d'Orbigny, 1853

?Heteraster D'ORBIGNY, 1853, Paléontologie française, Terrain crétacé, t. 6, p. 175. Genotype, *Spatangus oblongus* Brongniart, by original designation (p. 153).
Enallaster D'ORBIGNY, 1853, *idem*, p. 181.
Enallaster, DE LORIOL, 1884, Recueil zool. suisse, t. 1, p. 622.
?Heteraster, LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., t. 73 (Année 1919), p. 128.
?Heteraster, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 437.
Washitaster LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 271.
?Heteraster, ADKINS, 1928, Texas Univ. Bull. 2838, p. 287.
Washitaster, ADKINS, 1928, *idem*, p. 292.
Enallaster, IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, p. 58 (10).

Genotype, *Hemipneustes greenovii* Forbes, 1852, designated by de Loriol (1884, p. 621). As figured by d'Orbigny (1853, p. 183, pl. 849), who copies Forbes' figures, this is a medium-sized cordate echinoid having on the upper side a deep anterior sulcus, which emarginates the ambitus. The reniform peristome is far forward. The ovate periproct lies well up on the steeply truncated posterior end. In the odd ambulacrum pairs of circular pores alternate with elongated chevron-shaped pore pairs, which point diagonally forward, except at the outer end, where the pores are represented as all circular. In the anterior paired ambulacra the inner poriferous zones consist of small circular pores, close together; the outer zones consist of much larger elongated, slightly inclined pores. In the posterior ambulacra both zones are nearly alike, having inner very slightly elongated pores and outer longer slit-shaped pores.

De Loriol (1884, p. 622) considered the name *Heteraster* as a synonym of *Enallaster*, and he is followed by Cotteau (1890, p. 298). Lambert (1920, p. 129), Lambert and Thiéry (1924), and Adkins (1928) regard *Enallaster* as a junior synonym of *Heteraster*, which has page priority and, as Lambert points out, was published in the preceding signature, though both bear the date 1853. Article 28 of the International Code specifies that "if the names are of the same date, that of the first reviser shall stand."

The reference of *Heteraster* to *Enallaster* is here questioned because there appear to be differences that may be of at least subgeneric rank. D'Orbigny (1853, pl. 847) represents all the outer pores of the odd ambulacrum of *Heteraster oblongus* as being slitlike and of unequal lengths, and all the inner pores as small, circular, and evenly aligned, whereas the pore pairs of *Enallaster* are generally of two kinds—a long outer slit and a shorter inner slit, somewhat like an exclamation point, and two circular pores separated by a granule. Moreover, the inner edges of the two kinds of pore pairs are not aligned but staggered, the slits extending closer to the median line of the test than the line of the circular pores. These differences are shown in Ikins' (1940, pl. 7) figures of *Enallaster texanus* and *Heteraster oblongus*. Rarely, all the pores of the odd ambulacrum are of the

small, round kind, in perfect alignment. Substitution of slit-shaped pores for circular pores appears to be more or less at random.

Well-preserved individuals of *Enallaster texanus* commonly show multiple narrow granular bands or fascioles like those cited by Lambert (1927, p. 271) as characteristic of *Washitaster*, which is therefore placed in the synonymy of *Enallaster*.

ENALLASTER TEXANUS (Roemer)
Plate 33, figures 9–12

Toxaster texanus ROEMER, 1849, Texas, p. 393.
Toxaster texanus, ROEMER, 1852, Kreidebildungen von Texas, p. 85, pl. 10, figs. 3a–c.
Enallaster texasus, D'ORBIGNY, 1853, Paléontologie française, Terrain crétacé, t. 6, p. 184, pl. 850, figs. 1–7. Misprint for *texanus*.
Toxaster texanus, CONRAD, 1857, U. S. and Mexican Boundary Survey Rept., vol. 1, pt. 2, p. 145, pl. 1, figs. 2a–c.
Enallaster texanus, DESOR, 1858, Synopsis des échinides fossiles, p. 358.
Heteraster texanus, SHUMARD, 1860, Acad. Sci. St. Louis Trans., vol. 1, p. 585. List.
?Enallaster mexicanus COTTEAU, 1890, Soc. géol. France Bull., sér. 3, t. 18, p. 296, pl. 2, figs. 1–8.
Enallaster texanus, CLARK, 1891, Johns Hopkins Univ. Circ., vol. 10, no. 87, p. 77.
Enallaster texanus, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 78, pl. 39, figs. 2a–g.
Enallaster obliquatus CLARK, 1893, *idem*, p. 79, pl. 40, figs. 1a–l.
Enallaster texanus, CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 2, p. 151.
?Enallaster inflatus CRAGIN, 1893, *idem*, p. 150, pl. 24, fig. 13.
Enallaster texanus, HILL AND VAUGHAN, 1898, U. S. Geol. Survey Ann. Rept. 18, pt. 2, pl. 53, figs. 4a–b. After Clark, 1893.
Heteraster texanus, HILL, 1901, *idem*, Ann. Rept. 21, pt. 7, pl. 27, figs. 4a–b. After Clark, 1893.
?Enallaster böhmi DE LORIOL, 1904, Notes pour servir a l'étude des échinodermes, sér. 2, fasc. 2, p. 49, pl. 4, figs. 7–10.
Enallaster texanus, DE LORIOL, 1904, *idem*, pl. 4, figs. 5–5b, 6, 6c.
?Enallaster bravoensis BÖSE, 1910, Inst. geol. México Bol. 25, p. 168, p. 41, figs. 5–10; pl. 42, figs. 2–12; pl. 43, figs. 1, 2, 6, 7.
?Enallaster cf. *mexicanus*, BÖSE, 1910, *idem*, p. 165, pl. 39, figs. 9, 11; pl. 40, figs. 4, 5; pl. 41, fig. 1.
Enallaster texanus, BÖSE, 1910, *idem*, p. 166, pl. 40, figs. 6–10; pl. 41, figs. 2–4; pl. 42, fig. 1.
Enallaster cf. *obliquatus*, BÖSE, 1910, *idem*, p. 165, pl. 39, fig. 10.
Enallaster texanus, CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 86, pl. 39, figs. 2a–g. After Clark, 1893. Type of *Heteraster adkinsi* Lambert.
Enallaster obliquatus, CLARK, 1915, *idem*, p. 87, pl. 40, figs. 1a–l. After Clark, 1893, except fig. 1a.
?Enallaster traski WHITNEY, 1916, Bull. Am. Paleontology, vol. 5, no. 26, p. 99 (15), pl. 22 (8), figs. 1–3.
?Enallaster bravoensis, WHITNEY, 1916, *idem*, p. 100 (16), pl. 20 (6), figs. 3–5.
Heteraster obliquatus, LAMBERT, 1920, Soc. hist. et nat. de l'Yonne Bull., t. 73 (Année 1919), p. 130.
Enallaster texanus, ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 55, pl. 9, figs. 12, 13.
?Enallaster bravoensis, ADKINS AND WINTON, 1920, *idem*, p. 58, pl. 9, fig. 11.
Enallaster wenoensis ADKINS, 1920, Texas Univ. Bull. 1856, p. 112, pl. 5, fig. 3.
Enallaster bravoensis, ADKINS, 1920, *idem*, p. 114, pl. 8, fig. 4.
Hemiaster riovistae ADKINS, 1920, *idem*, p. 115, pl. 6, fig. 4; pl. 8, figs. 2, 3, 5.
Heteraster texanus, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 270.
Heteraster adkinsi LAMBERT, 1927, *idem*, p. 270.
?Heteraster inflatus, LAMBERT, 1927, *idem*, p. 270.
?Heteraster bravoensis, LAMBERT, 1927, *idem*, p. 270.
Washitaster riovistae, LAMBERT, 1927, *idem*, p. 271, text fig. 2.
Heteraster wenoensis, LAMBERT, 1927, *idem*, p. 271.
Heteraster obliquatus, LAMBERT, 1927, *idem*, p. 270.
Heteraster texanus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 289, pl. 3, fig. 1.
?Heteraster böhmi, ADKINS, 1928, *idem*, p. 290.
Heteraster texasus d'Orbigny, ADKINS, *idem*, p. 291. Adkins regards d'Orbigny's misspelling as a valid specific name, though d'Orbigny credits the species to Roemer. If the species figured by d'Orbigny is not Roemer's, the name must be regarded as a misidentification.
?Heteraster bravoensis, ADKINS, 1928, *idem*, p. 291.
Heteraster wenoensis, ADKINS, 1928, *idem*, p. 291.
?Heteraster traski, ADKINS, 1928, *idem*, p. 292.
?Heteraster mexicanus, ADKINS, 1928, *idem*, p. 292.
Heteraster cf. *mexicanus*, ADKINS, 1928, *idem*, pl 8, fig. 2.
Heteraster adkinsi, ADKINS, 1928, *idem*, p. 292, pl. 8, fig. 6.
Heteraster inflatus, ADKINS, 1928, *idem*, p. 298, pl. 8, fig. 1.
Washitaster riovistae, ADKINS, 1928, *idem*, p. 293, pl. 19, fig. 2.
Heteraster bravoensis, SMISER, 1936, Jour. Paleontology, vol. 10, p. 467, pl. 64, figs. 22–24.
Heteraster inflatus, SMISER, 1936, *idem*, p. 467, pl. 65, figs. 1–4.
Heteraster texasus, SMISER, 1936, *idem*, p. 468, pl. 64, figs. 15–18.
Heteraster texanus, SMISER, 1936, *idem*, p. 468, pl. 65, figs. 10, 11.
Heteraster adkinsi, SMISER, 1936, *idem*, p. 468, pl. 63, figs. 16–19.
Heteraster mexicanus, SMISER, 1936, *idem*, p. 468, pl. 64, figs. 19–21.
Heteraster obliquatus, SMISER, 1936, *idem*, p. 468, pl. 64, fig. 25.
Heteraster wenoensis, SMISER, 1936, *idem*, p. 469, pl. 65, figs. 5–7.

?Heteraster cf. *traski*, SMISER, 1936, *idem*, p. 469, pl. 65, fig. 8.
Enallaster texanus, IKINS, 1940, Bull. Am. Paleontology, vol. 25, no. 90, pl. 7 (4), figs. 1a–b.

Occurrence.—TEXAS: Many localities between the Red River and the Rio Grande.

Geologic horizon.—Trinity, Fredericksburg, and Washita groups.

Types.—According to Adkins (1928, p. 37), Roemer's (1852) types are in the Geological Institute of the University of Bonn. That of *Enallaster obliquatus* Clark is USNM 12237 (pl. 33, figs. 9–12). Types of *Enallaster wenoenis* Adkins and *Hemiaster riovistae* Adkins are at the United States National Museum on temporary deposit by the Bureau of Economic Geology, Austin, Texas.

Remarks.—The material examined, though plentiful, includes a large proportion of crushed, distorted, or otherwise imperfect individuals, and some of it is from uncertain horizons. It is possible that study of perfect specimens from well-authenticated horizons might enable one to recognize subspecies that under favorable conditions might be of stratigraphic value; but at present the species cannot be used for closer correlation than Comanche series.

Large individuals tend to be broader and flatter than the average, though the type of *Enallaster obliquatus* (pl. 33, figs. 9–12) is fairly high behind. Smaller ones are generally more globular. Some taper more rapidly toward the rear, as in d'Orbigny's figured specimen. The apparent location of the apical center ranges from nearly central, as in Roemer's figured specimen, to rather far back, as in Cotteau's figure of *Enallastsr mexicanus*, varying with the shape of the test; the actual distance from the apical center to the periproct, however, is generally nearly proportional to the size.

There seems to be little variation in the length and proportions of the paired petals —far more dependable features than the shape of the test. The arrangement of the pores in the odd petal is very variable. Most individuals show two kinds of pore pairs, pairs composed of a long and a short pore, like an exclamation point, alternating with pairs composed of two short pores, like a colon. The arrangement is not constant, even between individuals from the same bed. A few individuals, exemplified by the holotype of *Hemiaster riovistae* Adkins, contain only pore pairs of the colon kind, but the paratypes of *H. riovistae* contain several pairs of the exclamation-point kind. More commonly the number of exclamation points in the medial part of the row slightly exceeds the number of colons, and some individuals show many more exclamation points.

Heteraster adkinsi Lambert (1927) is based on figures by Clark (1915, pl. 37, figs. 2a–g) that ostensibly portray USNM 9857, but this number corresponds to six specimens of a *Hemiaster*, none of which could have served as their model.

ENALLASTER LONGISULCUS Adkins and Winton
Plate 33, figures 5, 6

Enallaster longisulcus ADKINS AND WINTON, 1920, Texas Univ. Bull. 1945, p. 55, pl. 9, figs. 4, 8–10.
Washitaster longisulcus, LAMBERT, 1927, Soc. géol. France Bull., ser. 4, t. 26, p. 271.
Washitaster longisulcus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 293, pl. 13, fig. 6.

Occurrence.—TEXAS: Cedar Creek branch of Nolands River 2 miles southeast of Blum (type 328*a* Texas Bureau of Economic Geology); road between Cleburne and Riovista 4½ miles south of Cleburne (USGS 11825, T. W. Stanton); north bank of Mustang Creek on road from Riovista to Blum (USGS 11826, T. W. Stanton); Johnson Branch, south side of Cleburne-Godley road, northwest of Cleburne (USGS 18576, Ralph Imlay); 4 miles north of Riovista, Johnson County; 0.3 mile due west of the intersection of highways 121 and 184, northeast of Birdville (USGS 19703, Renfro collection); east end of White lake dam, about 200 feet east of Oakland Boulevard 1.4 miles north of the intersection of Meadowbrook Drive and Oakland Boulevard (USGS 19692, Renfro collection).

Geologic horizon.—Washita group; Fort Worth limestone, Weno limestone, and Pawpaw formation.

Type.—Texas Bureau of Economic Geology, Austin, Texas, on temporary deposit at the United States National Museum.

Remarks.—This species, which varies considerably in shape, differs from *Enal-*

laster texanus in the location of its apical center, which is farther back. None of the specimens examined, including the type and paratype, show pore pairs consisting of a long and a short slit as is customary of *E. texanus*. In this respect they resemble the type of *Hemiaster riovistae* Adkins (1920), here referred to *E. texanus*. *E. longisulcus* may prove to be merely a subspecies of *E. texanus*.

Family ECHINOCORYTHIDAE

The Echinocorythidae, typified by *Echinocorys* Leske (1778, p. 175) are characterized by the elongated arrangement of their apical plates. Each paired plate is adjacent to its mate. The group of paired plates forms two longitudinal rows headed by the anterior ocular plate. This arrangement causes the paired ambulacral areas to diverge from two points or apices instead of one, as is customary in other families.

Genus PSEUDANANCHYS Pomel, 1883

Pseudananchys POMEL, 1883, Classification méthodique et genera des échinides, p. 45.
Holasteropsis ELBERT, 1902, Naturh. Ver. preuss. Rheinlande Verh., Band 58, p. 115.
Craginaster LAMBERT, 1903, Rev. crit. paléozoologie, t. 7, no. 4, p. 219. Genotype, *Holaster completus* Cragin, by monotypy.
Pseudamanchis, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 417. Typographical error.
Pseudananchys, ADKINS, 1928, Texas Univ. Bull. 2838, p. 285.

Genotype, *Ananchytes algira* Coquand (1862, p. 240, pl. 26, figs. 1, 2), from the Campanian of Algeria, by monotypy. This species is described by Coquand as being high and slightly conical, with an elongated apical system and a flat bottom. Its anterior ambulacral area is like the others and it is flush; the pores are elongated, the outer longer than the others. The copy of Coquand's memoir in the library of the Geological Survey lacks the plates, but *Holaster sylvaticus* Gauthier, which is said to be the same, is figured by Cotteau, Peron, and Gauthier (1876, fasc. 3, p. 66, pl. 5, figs. 1, 2).

The American species referred to *Pseudananchys* is remarkable in that there are madreporic pores in all four of the genital plates and also in the four paired ocular plates. Whether this is a feature of the genotype is unknown. Ordinarily these pores are revealed only by etching.

PSEUDANANCHYS COMPLETA (Cragin)
Plate 34, figures 7, 8

Holaster completus CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 155, pl. 24, fig. 10; pl. 25, fig. 14; pl. 27, figs. 6–8.
Holaster supernus CRAGIN, 1893, *idem*, p. 157.
Holaster simplex Shumard (part). CLARK, 1915, U. S. Geol. Survey Mon. 54, pl. 39, figs. 1a–g.
Stenonia supernus, ADKINS, 1918, Texas Univ. Bull. 1856, p. 105.
Pseudananchys completa, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 417.
Pseudananchys superna, LAMBERT AND THIÉRY, 1924, *idem*, p. 417.
Pseudananchys completa, LAMBERT, 1926, Soc. géol. France Bull., sér. 4, t. 26, p. 270.
Pseudananchys completus, ADKINS, 1928, Texas Univ. Bull. 2838, p. 286.
Pseudananchys supernus, ADKINS, 1928, *idem*, p. 286.

Occurrence.—TEXAS: South side of Cedar Mills, Grayson County (*fide* Cragin); 7 miles south of Denton and 2 miles east of Argyle, Denton County (type locality of *Holaster supernus*) (USGS 19712, Renfro collection); creek bed 1½ miles northeast of Argyle, 7½ miles southwest of Denton (USGS 18527, Ralph Imlay).

Geologic horizon.—Washita group: Grayson marl.

Type.—Probably University of Texas.

Remarks.—This species superficially resembles *Holaster laevis* (Brongniart), but it is not noticeably emarginate in front, its anterior ambulacral area is like the others, and its apical system is less extended. Moreover, it has eight separate madreporites, one in each of the four genital plates and in the four paired ocular plates. These are plainly visible in specimens from the Grayson marl at station 18527. All of the madreporites are inconspicuous unless the plates are worn or etched.

Genus HOLASTER Agassiz, 1836

Holaster AGASSIZ, 1836, Soc. sci. nat. Neuchâtel Mém., t. 1, p. 183.
Holaster, AGASSIZ, 1840, Catalogus ectyporum Echinodermatum fossilium, pp. 1, 15.
Holaster, AGASSIZ AND DESOR, 1847, Catalogue raisonnée des échinodermes, p. 132.
Holaster, D'ORBIGNY, 1853, Paléontologie française. Terrain crétacé, t. 6, p. 71.

Holaster, DESOR, 1858, Synopsis des échinides fossiles, p. 336.
Holaster, WRIGHT, 1881, British fossil Echinodermata from the Cretaceous formations, vol. 1, pp. 309–359.
Holaster, POMEL, 1883, Classification méthodique et genera des échinides, p. 45.
Holaster, LAMBERT AND THIÉRY, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 401.
Holaster, COOKE, 1942, Jour. Paleontology, vol. 16, no. 1, p. 52.

Genotype, *Spatangus nodulosus* Goldfuss, 1829, from the Cenomanian of Europe, designated by Lambert and Thiéry (1924). This species has been identified by Wright as *Holaster laevis* (Brongniart, 1822). It is a tall heart-shaped echinoid with a shallow anterior sulcus and a flattish base. Its apical system is elongated; the anterior paired oculars are in contact with each other and separate the four genital plates from one another. Consequently, the paired ambulacral areas do not radiate from one point but have two centers. The anterior ambulacral area has small pores very close together; the pores in the paired ambulacral areas are elongated.

HOLASTER LAEVIS (Brongniart)

Ananchytes carinata (Leske). LAMARCK, 1816, Histoire naturelle des animaux sans vertèbres, t. 3, p. 26.
Spatangus laevis (Deluc MS) BRONGNIART, 1822, Description géologique des environs de Paris, pp. 97, 399, pl. 9, figs. 12a–c.
Spatangus nodulosus GOLDFUSS, 1829, Petrefacta Germaniae [edition 2, 1862], pt. 1, p. 139, pl. 45, figs. 6a–c.
Holaster carinatus, D'ORBIGNY, 1853, Paléontologie française, Terrain crétacé, t. 6, p. 104, pl. 818.
Holaster laevis, D'ORBIGNY, 1853, *idem*, p. 83, pl. 812.
Holaster simplex SHUMARD, 1853, Natural history of the Red River of Louisiana, Appendix E, p. 210.
Holaster simplex, SHUMARD, 1854, Marcy's Exploration of the Red River of Louisiana, Appendix E, p. 184, pl. 3, fig. 2.
Holaster coyanchesi MARCOU, 1858, Geology of North America, p. 40, pl. 3, figs. 3a–c.
Holaster comanchesi, DESOR, 1858, Synopsis des échinides fossiles, p. 449.
Holaster simplex, DESOR, *idem*, p. 450.
Holaster laevis, WRIGHT, 1881, British fossil Echinodermata from the Cretaceous formations, p. 310, pl. 72, figs. 1a–f. Includes European synonymy.
Holaster simplex, CLARK, 1893, U. S. Geol. Survey Bull. 97, p. 76, pl. 38, figs. 1a–g; pl. 39, figs. 1a–d.
Holaster nanus CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 156. pl. 24, fig. 14; pl. 25, fig. 11.
Holaster simplex, CRAGIN, 1893, *idem*, p. 157, pl. 25, fig. 13.
Holaster simplex (part), CLARK, 1915, U. S. Geol. Survey Mon. 54, p. 85, p. 34, figs. 3a–b; pl. 38, figs. 1a–j. Not pl. 39, figs. 1a–g (=*Pseudananchys completus* (Cragin)).
Holaster simplex, ADKINS AND WINTON, 1919, Texas Univ. Bull. 1945, p. 51, pl. 8, figs. 5, 6; pl. 9, figs. 18, 19.
Holaster simplex, WINTON, 1925, Texas Univ. Bull. 2544, p. 54, pl. 13, figs. 1–3.
Holaster simplex, LAMBERT, 1927, Soc. géol. France Bull., sér. 4, t. 26, p. 269.
Holaster nodulosus, LAMBERT, 1927, *idem*, p. 269.
Holaster nanus, LAMBERT, 1927, *idem*, p. 269.
Holaster simplex, ADKINS, 1928, Texas Univ. Bull. 2838, p. 285, pl. 14, figs. 1, 3.
Holaster comanchesi, ADKINS, 1928, *idem*, p. 285.
Holaster nanus, ADKINS, 1928, *idem*, p. 285.
Holaster nodulosus, ADKINS, 1928, *idem*, p. 285.
Holaster nanus, JONES, 1938, Geol. Soc. America Bull., vol. 49, no. 1, p. 134, pl. 13, figs. 11–16.

Occurrence.—OLKAHOMA: Fort Washita, Bryan County (type, *fide* Shumard); bluff on small branch at road crossing one-third mile northeast of Katy Railroad bridge 5½ miles north of Denison, Texas, in Bryan County, from lower 18 feet of section (USGS 9690, L. W. Stephenson).

TEXAS: Railroad cuts north of the oil mill in northwest Denison, Grayson County (USGS 1583, Frank Burns); 2½ miles north of Denison (USGS 1549, R. T. Hill and T. W. Stanton); cut on Frisco Railroad 2 miles north of Denison station (USGS 9680, L. W. Stephenson); branch of Hickory Creek one-fourth mile east of road about 2.4 miles north of Ponder, Denton County (USGS 18518, Ralph Imlay); about 1 mile south of Crum, Denton County, 0.4 mile west of overpass on Decatur-Denton Highway (USGS 18520, Ralph Imlay); hilltop about one-half mile west of Roanoke, Denton County (USGS 18523, Ralph Imlay); cut on U. S. Highway 114 about 2 miles west of Roanoke (USGS 18524, Ralph Imlay); Haslit-Justin road near Elizabeth Creek about 3 miles north of Haslit, Denton County (USGS 18531, Ralph Imlay); foot of Seventh Street, Fort Worth (USGS 1570); near depot, Fort Worth (USGS 1578); Fort Worth (USGS 9722, L. W. Stephenson); Fossil Creek north of Fort Worth and southwest of Watanga (USGS

9546, O. B. Hopkins); Big Fossil Creek, road to Blue Mound and Haslit, 4 miles south of Blue Mound, 9 miles north of Court House at Fort Worth (USGS 18540, Ralph Imlay); Martin Branch at crossing of Glen Rose road about 6 miles west of Cleburne, Johnson County (USGS 11830, T. W. Stanton); "Chara" Creek 20 yards southeast of Frisco Railroad and about 8 miles southwest of center of Fort Worth (USGS 11744, T. W. Stanton and Gayle Scott); cut on I. & G. RR. between Austin and dam (USGS 64, R. T. Hill); Mount Bonnel, near Austin (USNM 12237); "The Gap," near Austin, (USNM 12235); Georgetown, Williamson County (USNM 12238); 1 mile southeast of station at Kent, Culberson County (USGS 1931, T. W. Stanton); one-fourth mile southwest of station at Kent (USGS 1932, T. W. Stanton); hill southwest of Kent (USGS 13944, N. H. Darton); 3 miles west of Boracho and 13 miles west of Kent, lower 25 feet of section in mesa (T. W. Stanton and W. P. Popenoe); south end of Sierra Blanca Peak, Hudspeth County (N. H. Darton); pass between north and south peaks, Sierra Blanca Mountains (USGS 1914, T. W. Stanton); east side Black Mountain, Trans-Pecos (USGS 3610, G. B. Richardson); south side of Rio Grande 4 miles west of El Paso (USNM 1689, E. A. Mearns).

Geologic horizon.—Washita group: Georgetown limestone and equivalents.

Remarks.—Variations in the height of this species have little significance, for high and low individuals occur together. The small form called *Holaster nanus* by Cragin appears to be merely young. According to Lambert (1926, p. 269) small individuals from the middle part of the Washita group (Weno clay) cannot be distinguished from the European *Holaster nodulosus* (Goldfuss), and that species as figured by Goldfuss and by d'Orbigny (under the name *Holaster carinatus*) certainly resembles the American species very closely, though it seems to have somewhat larger tubercles. Wright's (1881) identification of *Spatangus nodulosus* Goldfuss as *S. laevis* Brongniart may be questionable, but it is probably correct. Brongniart reports his species from the "glauconie crayeuse (craie chloritée)" at La Perte du Rhone near Bellegarde. Wright figures it from the Upper Greensand at Chute Farm, Wiltshire.

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NEW WASHITA FORAMINIFERA

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ABSTRACT—Thirty-one species of Foraminifera, of which 29 are new, are described from the Washita group (Lower Cretaceous) of southern Oklahoma and northern Texas. Four new genera are described, *Polychasmina*, belonging to the Reophacidae, *Meandrospira* of the Ophthalmidiidae, *Acruliammina* of the Placopsilinidae and *Planomalina*, a new member of the Anomalinidae. The geologic range of three genera, *Nodophthalmidium*, *Ophthalmina* and *Eouvigerina*, is extended downward to include the Lower Cretaceous.

INTRODUCTION

THE Foraminifera here described from the Washita group of southern Oklahoma and northern Texas are a few of the additional new species encountered therein by us during the past eight years of study. As the war has delayed the completion of our monograph on the Washita Foraminifera, we deem it advisable to publish in advance some of the more distinctive undescribed species, in order that they may be available for use by economic workers on the Gulf Coast and others. The present paper is thus strictly taxonomic in character, like those previously published on Washita Foraminifera by us (Tappan, 1940, 1943 and 1944; Loeblich and Tappan, 1941). Many new and still undescribed species remain and will be included in the above-mentioned monograph. With the completion of this necessary preliminary taxonomic work therein, we will also present the stratigraphic range and areal distribution of all species of Foraminifera recorded from the Washita, with a discussion of their ecologic habitat and their relationships to the species in the underlying and overlying formations. The evidence presented by the Foraminifera as to the subdivision and correlation of the Washita group will also be discussed in the forthcoming paper, and compared with the evidence supplied by other groups of invertebrates.

In the present paper, 31 species of Foraminifera are described, of which 29 are new, and the others are redescribed in the light of new and better specimens. These represent 26 genera, of which four are new, and 14 families. The new genera are *Polychasmina* (Reophacidae), *Meandrospira* (Ophthalmidiidae), *Acruliammina* (Placopsilinidae), and *Planomalina* (Anomalinidae). In addition, the geologic ranges of three genera are extended. *Ophthalmina*, heretofore recorded only from the Recent, *Nodophthalmidium*, formerly known from Tertiary and Recent, and *Eouvigerina*, known only from the Upper Cretaceous, all have their known geologic ranges extended downward into the Lower Cretaceous.

The collection of samples during the summers of 1940 and 1941 was financed by a grant from the Penrose Bequest of The Geological Society of America. Permission was obtained from the Society to publish the present paper before the completion of the project. Acknowledgment is also made of a grant from the Tulane University Faculty Research Fund for the purchase of optical equipment and microscope accessories used in this study.

All samples used in this study were collected, washed and sorted, and types selected by the writers, who were assisted in the field during part of this work by Professor F. G. Tappan, of the University of Oklahoma. Illustrations were made by Helen Tappan Loeblich, with the aid of a camera lucida.

The writers are indebted to Dr. J. A. Cushman for reading and criticizing the manuscript, for comparing the types with those in his collections, and for offering valuable suggestions concerning many of the species. They are also indebted to Dr. Cecil G. Lalicker, of the University of Oklahoma, for examining the new members of the family Textulariidae and for suggestions concerning those species.

All types are temporarily in the writers'

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collection, pending the completion of the Washita study, at which time the holotypes, and illustrated paratypes, topotypes and hypotypes are to be deposited in the Cushman Collection at the Cushman Laboratory for Foraminiferal Research at Sharon, Massachusetts. Other paratypes, topotypes and hypotypes are catalogued in the writers' collection.

LOCALITIES AND SAMPLES

The following localities are those from which the illustrated types were selected. References to the occurrence of these species in other horizons and localities is limited at present for the purpose of brevity. Although the occurrence in other formations than the type horizon is noted, not all of the additional localities are listed. A more complete geographic and vertical range of these species and others will be presented in the forthcoming monograph concerning the Washita Foraminifera. In the present paper only outcrop samples have been used, and geographic and geologic ranges given do not include any reference to subsurface occurrence, nor to occurrence in the post-Buda subsurface formation, the Maness, which is not known to appear at the surface.

HTL 1, April 1937.—Grayson formation. At Grayson Bluff, a high, southwest-facing bluff on Denton Creek, 3½ miles northeast of Roanoke, 2 miles by road east of the Fort Worth-Denton Highway, Denton County, Texas. Sample 38, from which types were selected, consists of 2 feet of section, 6 feet above the base of the exposure, in the basal zone of fine gray clay marl, which has a total thickness here of 11 feet.

HTL 9, July 1938.—Fort Worth formation. In a deep road cut on the west side of Highway 75, the Denison-Durant highway, 1000 feet north of Calvary Cemetery, half a mile north of the Texas Highway Department Information station, 1.6 miles north of Main Street in Denison, Grayson County, Texas. Sample 203, from which types were selected, consists of 3 feet of dark-gray and yellow shale, 10 feet above the base of the exposure.

HTL 13, August 1939.—Duck Creek formation. On the west bank of the Red River, in the SW ¼ sec. 22, T. 8 S., R. 2 E., on the southwest side of Horseshoe Bend, Love County, Oklahoma. Sample 121, from which types were selected, consists of 5½ feet of alternating gray shale and marly limes, 6½ feet below the base of the Fort Worth basal fucoid-bearing limestones.

HTL 22, August 1939.—Weno formation. In the north bank of a tributary to Corocran Creek. in the SE ¼ sec. 11, T. 8 S., R. 2 W., west of the road between sections 11 and 12, in Love County, Oklahoma. Sample 87 consists of 5½ feet of yellow and gray fossiliferous shale, with iron nodules, 3 feet below the "Quarry lime," a 2½ foot sandstone bed, which caps the exposure.

HTL 32, July 1938.—Paw Paw formation. In the bank of Little Mineral Creek, 500 feet south of the bridge of the Locust road, about 1 mile southeast of Fink (locally called Georgetown), in northeastern Grayson County, Texas. Sample 187 is from the top 6 inches of the Paw Paw formation, just below the basal limestone ledge of the Main Street formation.

HTL 36, September 1938.—Main Street formation. In a road cut, on the road leading eastward to Grayson Bluff (HTL 1) from the Fort Worth-Denton highway, about 1 mile east of the highway, 3½ miles northeast of Roanoke, Denton County, Texas. Sample 230 consist of 5½ feet of section, of nodular limes and marls, with two thin limestone beds (4 to 6 inches thick) that are finely crystalline and contain numerous fossil fragments, in the middle of the zone. The upper part of this zone contains *Turrilites brazoensis*, the lower part has *Exogyra arietina*, and immediately beneath this zone are irregular thin-bedded nodular limes containing abundant *Kingena wacoensis*.

HTL 40, September 1938.—Weno formation. In the south bank of Denton Creek, just west of Highway 377, the Fort Worth-Denton highway, where it crosses Denton Creek, 3½ miles northeast of Roanoke, Denton County, Texas. Sample 236 consists of the uppermost 4 feet of section exposed, the stream gravel being deposited above. Sample 235 consists of 5½ feet of section, immediately beneath sample 236, and 5½ feet above the base of the exposure. The entire section is composed of fissile blue-gray shales, containing pyritized fossils.

HTL 43, September 1938.—Denton formation. One-half mile east of the underpass under the Frisco Railroad, in the banks of a small stream, 1.9 miles from where the "Frisco road" branches from the Old Cleburne Road and crosses the Frisco tracks, 0.3 miles south of Berry Street in Fort Worth, Tarrant County, Texas. Sample 242 consists of 5½ feet of section, taken just below a small dam of the stream. Sample 243 consists of 5½ feet of section, taken just above the dam, to the east of sample 242, and stratigraphically just above that sample. Both samples were of yellow brown shales.

HTL 46, September 1938.—Paw Paw formation. On the hillside on the west side of the Fort Worth-Burleson Highway, where the highway swings southward near the top of the hill, one-fourth mile southeast of where the Fort Worth-Everman road turns from the Fort Worth-Burleson highway, southeast of Fort Worth, Tarrant County, Texas. The Paw Paw consists of fossiliferous brownish clay.

Sample 258. Top 3 feet of the Paw Paw formation exposed.

257. Just below sample 258, 5½ feet of section.

256. Just below sample 257, 5½ feet of section.
255. Lowest 5½ feet of the Paw Paw formation, just below sample 256, just above the Weno formation.

HTL 46, September 1938.—Weno formation. In a roadside ditch and road cut just north of and down hill from the Paw Paw formation outcrop at this locality. The Weno consists of alternating thin limestones and thicker marl beds.

One-foot limestone ledge at the top of the Weno formation, just below the Paw Paw, no sample taken.

Sample 254. Just below the limestone ledge, 2¾ feet.
253. Just below sample 254, 2¾ feet.
1-foot limestone bed, no sample taken.
252. Just below the limestone bed, 2¾ feet.
251. Just below sample 252, base of the exposure, 2¾ feet.

HTL 47, September 1938.—Weno formation. On the south bank of a tributary of Sycamore Creek, which was dammed to form Katy Lake one-fourth mile east of and below the Katy Lake Dam, southeast of Fort Worth, Tarrant County, Texas. A total of 11 feet of the Weno is exposed, as well as the upper part of the underlying Denton formation. The Weno consists of alternating limes and light-gray marls and yellowish and brownish clays.

Sample 263. Uppermost 2¾ feet exposed.
262. Just below sample 263, 2¾ feet.
261. Just below sample 262, 2¾ feet.
260. Just below sample 261, base of the Weno formation, just above the Upper Denton *Gryphea washitensis* shell breccia, 2¾ feet.

HTL 55, June 1939.—Paw Paw formation. In road cuts on both sides of the road, at the western edge of the Federal Narcotic Farm, southeast of Fort Worth, Tarrant County, Texas. Samples 281 and 282 are from the north side of the road, and samples 283 to 286 are from the south side of the road.

Sample 281. Top of the Paw Paw formation, just below the Main Street, 2 feet of yellowish shale, grading into gray at the base.
Grayish 1½-foot limestone ledge, no sample taken.
282. Bluish gray shale, just below the limestone ledge, 2 feet of section.
283. Stratigraphically just beneath sample 282, but taken from the south side of the road. Grayish clay, 2 feet of section.
284. Just below sample 283, grayish clay, 1 foot of section.
285. Just below sample 284, reddish and yellowish clay, 4 feet of section.
286. Just below sample 285, reddish and yellowish clay, 2 feet of section.

HTL 60, June 1939.—Duck Creek formation. In a low north-facing cliff, on the south bank of a small creek, a short distance north of the road, 0.1 mile east of the bridge which crosses the creek, 0.9 miles east of Fink (locally called Georgetown), in Grayson County, Texas. The Duck Creek formation is composed of alternating heavy limes and thin marls. Sample 303, from which types were selected, was from the basal 1 foot exposed in the creek bank.

HTL 65, August 1939.—Paw Paw formation. In a road cut and roadside ditch, on the west bank of the Washita River, due east of Woodville, in the northeast ¼ sec. 19, T. 7 S., R. 7 E., Marshall County, Texas. This outcrop, as well as the town of Woodville, is now inundated by Lake Texhoma, which was formed by a dam across the Red River. Sample 95 is from the base of the Paw Paw formation, 5½ feet of blue-gray shales and brown sandy seams with many limonite concretions, just above the "Quarry lime," a 3-foot sandstone forming the top of the underlying Weno formation.

HTL 65, August 1939.—Weno formation. In the road cut, just below and slightly east of the Paw Paw outcrop at this locality. Sample 94 was taken immediately beneath the 3-foot "Quarry lime," which is the top of the formation.

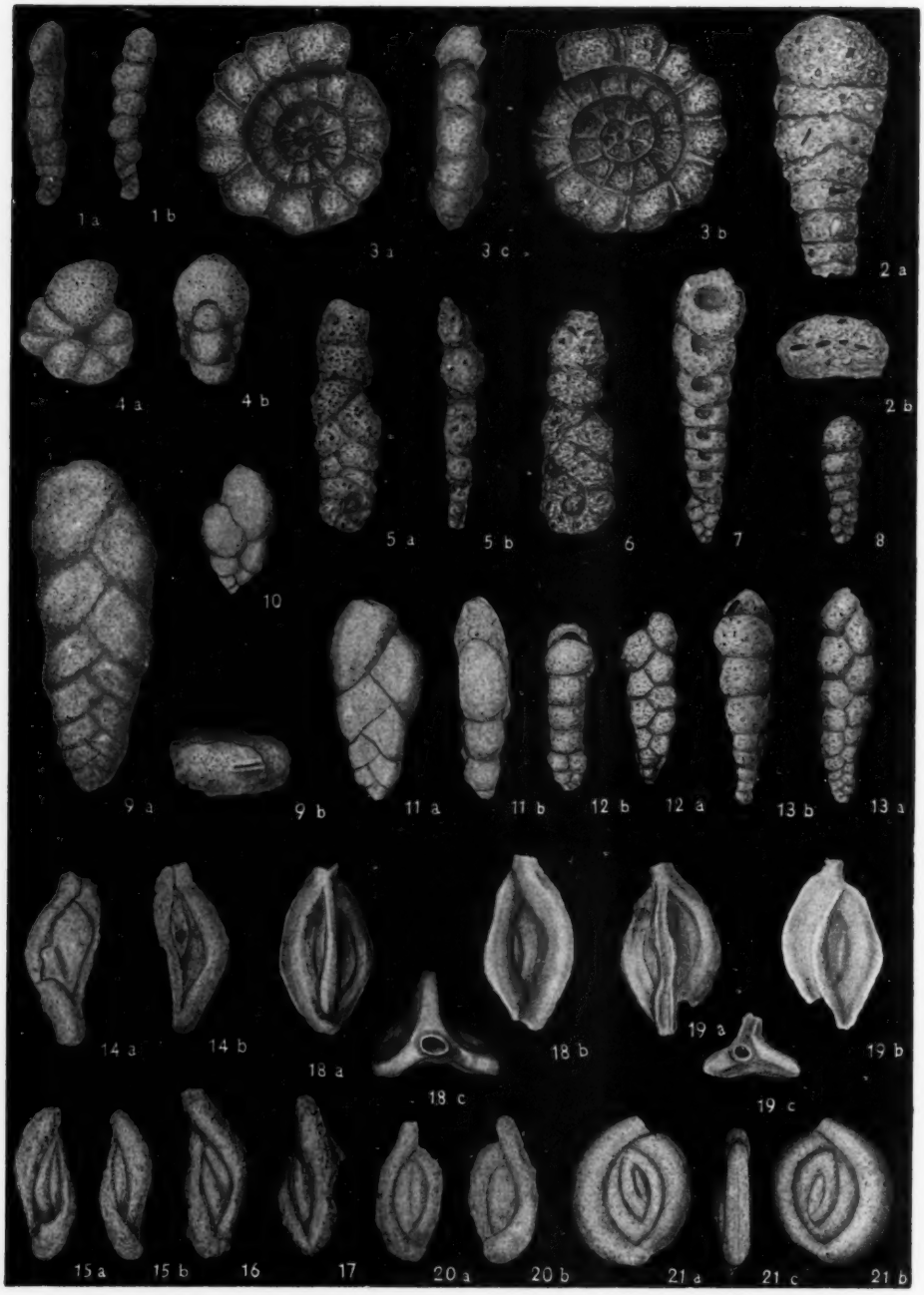
HTL 70, August 1939.—Fort Worth formation. In a road cut on the north side of the road, 1 mile west of Kingston, on the south boundary of the SW ¼ sec. 25, T. 6 S., R. 5 E., Marshall County, Oklahoma. Sample 101 was from the lower 2 feet of the 5½-foot exposure. It consists of brownish yellow shale.

HTL 72, December 1937.—Georgetown formation. In a road cut on Mount Bonnell, Austin, Texas. According to Dr. R. H. Cuyler, this is the equivalent of the Fort Worth formation to the north. Sample 312 was taken from 35 to 40 feet above the base, from alternating limestones and marls.

HTL 80, July 1940.—Denton formation. In a road cut on the east side of U. S. Highway 77, 2.3 miles south of the south end of the bridge across the Red River, where the highway bends southeast, in Cooke County, Texas. Sample 330 is from the basal 5½ feet exposed, consisting of bluish and reddish clays, platy at the base. *Gervilliopsis invaginata* occurs in this zone, selenite is abundant in the washed residue of the sample.

HTL 81, July 1940.—Denton formation. In the Gainesville Brick Pit, an unworked pit southeast of Gainesville, Cooke County, Texas.

Sample 341. One foot of *Gryphea washitensis* shell breccia at the top, 1½ feet of gray clay just below, and 8 inches of gray clay and shale with ironstone concretions, making a total of 3 feet 2 inches.
340. Dark-grayish-blue shale with ironstone concretions, 5½ feet, upper part brownish with numerous small fossil fragments.
339. Dark-bluish-gray clay with dark ironstone concretions, micaceous and glauconitic, 5½ feet. A 6-inch red ironstone bed with numerous fos-



Loeblich and Tappan, Washita (Comanche) Foraminifera

sils, including *Protocardia*, occurs 2 feet above the base of the sample.
338. Dark-blue-gray clay, 5½ feet. The washed residue contains selenite, pyrite, glauconite, mica and quartz grains.
337. Dark-bluish-gray clay with ironstone concretions, 5½ feet.
336. Dark-blue clay with thin layers of soft yellowish-brown sandstone and ironstone concretions, 5½ feet.
335. Lithology same as above sample, 5½ feet.
334. Dark-bluish-gray clay, *Gervilliopsis invaginata*, 5½ feet.
333. Dark-bluish-gray clay, 5½ feet, base of section exposed.

HTL 90, July 1940.—Grayson (Del Rio) formation. On the west bank of Shoal Creek, just south of the 34th Street bridge, and just north of a small fault, in Austin, Travis County, Texas. Sample 369 was taken from 5½ feet of section, 5½ feet below the top of the exposure, 27½ feet above the base of the exposure.

HTL 96, July 1940.—Georgetown formation. Along Smith Branch, the first main creek east of the town of Georgetown, from 1 mile north of the highway, upstream to Highway 104, Williamson County, Texas. Seven samples were taken, No. 394 being farthest from the highway, No. 400 being nearest. The stratigraphic relationship of the various samples is uncertain, because of faulting in this area. Only the samples from which specimens are recorded in the present paper are listed below.

Sample 396. Marls between limestone ledges containing large fucoids, and *Macraster*, upstream from sample 394.
397. Upstream from sample 396, zone contains large *Exogyra americana*, *Macraster elegans* and *Pleurotomaria austinensis*.
398. Upstream from sample 397, *Kingena* sp., *Macraster elegans*.
399. Four feet of *Gryphea washitensis* breccia, upstream from sample 398, at a concrete ford across the stream.

HTL 97, July 1940.—Main Street formation. Just east of the railroad underpass under the Santa Fe Railroad, on the Belton-Temple Highway, U. S. Highway 81, northeast of Belton, Bell County, Texas. Sample 401 consists of marl breaks between limestone ledges for 5 feet of section.

HTL 98, July 1940.—Main Street formation. Just downstream from the railroad bridge at South Bosque Station, on the west bank of the South Bosque River, McLennan County, Texas. Sample 402 is from the basal 4½ feet exposed in the cliff, consisting of thin-bedded argillaceous, bluish soft fossiliferous limestone, locally sandy and platy at the top. *Turrilites brazoensis* and *Exogyra arietina* occur here. This is part of the Del Rio clay, but the equivalent of the Main Street formation of the north, according to Adkins (1924, page 50). The remainder of the exposure is the equivalent of the Grayson formation.

HTL 102, July 1940.—Main Street formation. Road cut on the south side of the Godley-Cleburne road, just uphill from the bridge across Nolans River, 4.8 miles southeast of the Santa Fe Railroad station in Godley, Johnson County, Texas. Sample 418 is from the upper 2½ feet exposed, yellow-gray marl zones between limestone ledges.

HTL 103, July 1940.—Grayson formation. Steep, northwest-facing slope, 0.75 mile due east of Burleson, 0.2 miles northeast of the old

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EXPLANATION OF PLATE 35

Reophacidae to Miliolidae

FIGS. *1a–b—Reophax incompta* Loeblich and Tappan, n. sp. Side views of holotype; ×53. (p. 242)
2a–b—Polychasmina pawpawensis Loeblich and Tappan, n. sp. *2a*, Side view of holotype; *2b*, top view; ×10. (p. 242)
3a–c—Trochamminoides coronus Loeblich and Tappan, n. sp. *3a, b*, Side views of holotype; *3c*, edge view; ×117. (p. 243)
4a–b—Haplophragmoides cushmani Loeblich and Tappan, n. sp. *4a*, Side view; *4b*, edge view of holotype; ×53. (p. 244)
5a–6—Ammobaculoides gainesvillensis Loeblich and Tappan, n. sp. *5a*, Side view of holotype; *5b*, edge view; *6*, side view of paratype; ×53. (p. 244)
7–8—Bigenerina clavellata Loeblich and Tappan, n. sp. *7*, Holotype; *8*, paratype; ×46. (p. 245)
9a–11b—Siphotextularia washitensis Loeblich and Tappan, n. sp. *9a*, Side view of holotype; *9b*, top view; *10, 11a*, side views of paratypes; *11b*, edge view; ×76. (p. 245)
12a–13b—Gaudryina bosquensis Loeblich and Tappan, n. sp. *12a*, Side view of holotype; *12b*, edge view; *13a*, side view of paratype; *13b*, edge view; ×27. (p. 245)
14a–17—Quinqueloculina aeschria Loeblich and Tappan, n. sp. *14a, b*, Side views of holotype; *15a, b, 16, 17*, side views of paratypes; ×76. (p. 246)
18a–19c—Quinqueloculina lirellangula Loeblich and Tappan, n. sp. *18a, b*, Side views of holotype; *18c*, top view; *19a, b*, side views of paratype; *19c*, top view; ×53. (p. 247)
20a–b—Quinqueloculina sabella Loeblich and Tappan, n. sp. Side views of holotype; ×76. (p. 247)
21a–c—Spiroloculina ophionea Loeblich and Tappan, n. sp. *21a, b*, Side views of holotype; *21c*, edge view; ×76. (p. 247)

Burleson-Alvarado road, in Johnson County, Texas. Sample 419 is from the basal 5½ feet exposed in the cliff, consisting of yellow gray marls, *Gryphea mucronata*.

HTL 176, August 1941.—Weno formation. In a road cut and roadside ditch on the Fort Worth-Mansfield road, 0.3 miles south of the bridge where the highway crosses Sycamore Creek, in Tarrant County, Texas.

Sample 686. Ten feet of light-yellow-gray marls interbedded with limestone, from the road cut.
687. Three feet of section, gray marl, about 5 feet lower stratigraphically than sample 686, and in the roadside ditch.

HTL 199, April 1943.—Paw Paw formation. On a west-facing hillside, on the west side of the Old Mansfield Road, between the Glen Garden Country Club and Sycamore Creek, 3 miles southeast of Fort Worth, Tarrant County, Texas. The Paw Paw here consists of reddish and yellowish brown sandy clays.

Sample 735. Upper six feet exposed.
736. Lower six feet exposed, immediately beneath 735.

DESCRIPTION OF FORAMINIFERA

Family REOPHACIDAE
Subfamily REOPHACINAE
Genus REOPHAX Montfort, 1808

REOPHAX INCOMPTA Loeblich and Tappan, n. sp.

Plate 35, figures 1a, 1b; text figure 1

Test free, small, elongate, slightly compressed, with rounded periphery; chambers numerous, arranged in a roughly linear series and increasing somewhat irregularly in size, early chambers occasionally cuneate and irregularly arranged, so that an almost biserial condition is simulated, as shown by the paratypes of text figure 1, between 7 and 10 chambers in the average specimen, 9 in the holotype; sutures distinct, depressed, straight or slightly arched, horizontal or occasionally at an angle; wall finely arenaceous, with considerable cement, surface smoothly finished; aperture terminal, rounded.

Length of holotype 0.45 mm., greatest breadth 0.107 mm. Length of the specimens ranges from 0.407 mm. to 0.533 mm.

Types.—Holotype (Cushman Coll. no. 45595) and paratypes (Loeblich Coll. no. 1046) from the Weno formation at locality HTL 40, sample 236. Paratypes of text figure 1 (Cushman Coll. no. 45617) from sample 235 of the same locality. Paratypes (Loeblich Coll no. 1047) from the Weno formation at HTL 47, sample 261.

Remarks.—This species differs from *Reophax pseudobacillaris* Cushman in the much smaller size, being about one-fourth as large as that species. The chambers are also more irregularly arranged and more nearly globular in shape, the sutures more depressed and the test less tapering.

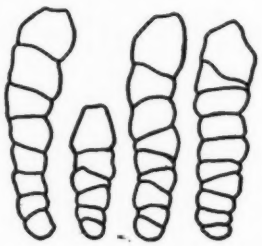


FIG. 1—*Reophax incompta* Loeblich and Tappan, n. sp. Paratypes, showing irregular development and wedgelike chambers, which may give a pseudobiserial appearance. All ×53.

Genus POLYCHASMINA Loeblich and Tappan, n. gen.

Genotype, *Polychasmina pawpawensis* Loeblich and Tappan, n. sp.

Test free, flattened, composed of a linear series of chambers; wall thick, coarsely arenaceous, interior labyrinthic; aperture terminal, consisting of a single row of elongate slits, whose trend parallels the flattened sides of the test.

This genus is similar to *Haplostiche*, differing in the flattened test and single row of elongate slits which form the aperture, contrasting with the irregular openings of random arrangement which form the cribrate aperture of *Haplostiche*.

POLYCHASMINA PAWPAWENSIS Loeblich and Tappan, n. sp.

Plate 36, figures 2a, 2b, text figures 2A–E

Test free, large, elongate, slightly compressed; chambers numerous, broad and low, as many as 10 chambers in well-developed specimens, eight in the holotype, chambers usually increasing gradually in size, but occasionally irregular in arrangement, so that rarely bifurcation of the test may occur, with later chambers of smaller size than the earlier ones of the test, as in text figures 2C and D, interior labyrinthic;

sutures distinct, depressed, varying from straight to slightly arched or sinuate; wall very thick, very coarsely arenaceous, insoluble in acid, with whitish or iron-stained cement, dark-colored mineral grains mixed with the quartz giving many tests a speckled

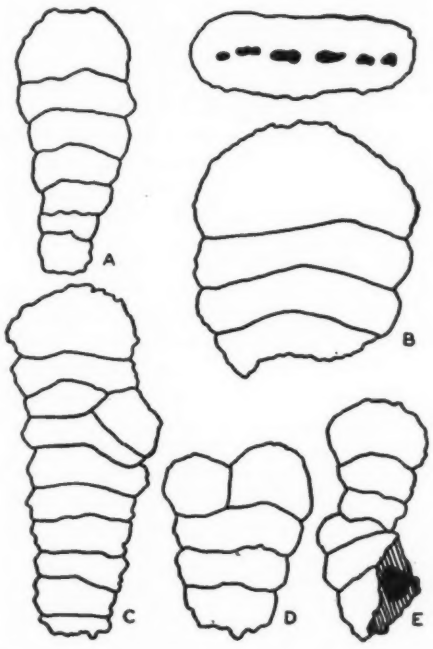


FIG. 2—*Polychasmina pawpawensis* Loeblich and Tappan, n. sp. *A*, Holotype. *B–E*, paratypes, showing variations. *B*, side and top views of paratype showing apertural characteristics. *C*, side view of paratype showing bifurcation of the last chamber. *D*, paratype, a broken test with later chambers of smaller diameter than the previous ones, probably because of bifurcation. All ×10.

appearance, although the light-colored quartz grains and cement generally form a whitish or yellowish test, surface somewhat rough; aperture terminal, consisting of a series of elongate slits in a single row, in general about four to six distinct openings occur on a well-developed specimen.

Length of holotype 3.55 mm., greatest breadth 1.53 mm., greatest thickness 1.06 mm. Length of paratype in text figure 2C is 4.7 mm., greatest breadth of paratype of text figure 2B is 2.98 mm.

Types.—Holotype (Cushman Coll. no. 45596), paratypes of text figure 2 (Cushman Coll. no. 45597) and paratypes (Loeblich Coll. no. 1048) from the Paw Paw formation at locality HTL 32, sample 187. Paratypes (Loeblich Coll. no. 1049) from the Weno formation at locality HTL 65, sample 94.

Remarks.—This species might be confused superficially with *Haplostiche texana* (Conrad), with which it occurs, but it differs in being compressed, rather than circular in cross section, in possessing somewhat arched sutures, in the aperture being formed of a single row of slits, in the tendency to branch, and in lacking the characteristic tapering of the last chamber to form a neck, which is found in *Haplostiche texana*.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMIINAE
Genus TROCHAMMINOIDES Cushman, 1910
TROCHAMMINOIDES CORONUS Loeblich and Tappan, n. sp.
Plate 35, figures 3a–c.

Test free, small, discoidal, planispirally coiled and evolute, periphery rounded; chambers numerous and small, 12 to 14 in the last whorl, as many as three complete whorls may be seen; sutures distinct, depressed, straight, somewhat thickened; wall finely arenaceous, occasionally iron-stained; aperture a low arch at the base of the apertural face of the last-formed chamber, on the periphery.

Greatest diameter of holotype 0.25 mm., least diameter 0.221 mm., greatest thickness 0.071 mm. Other specimens vary in greatest diameter between 0.158 mm. and 0.281 mm.

Types.—Holotype (Cushman Coll. no. 45598) and paratypes (Loeblich Coll. no. 1050) from the Georgetown formation at locality HTL 96, sample 397, Paratypes (Cushman Coll. no. 45618) from sample 396 at the same locality. We also have this species in sample 398 at this locality and in the Georgetown formation at locality HTL 72, sample 312.

Remarks.—This species differs from *Trochamminoides proteus* (Karrer) in being about one-third as large, in possessing more chambers in the last whorl, and in having a much more regular development, more thickened sutures, and a more restricted aperture.

It somewhat resembles *Trochammina tolypa* Deecke in the planispiral, discoidal test, but differs in the much smaller size,

being only about one-tenth as large, in possessing more chambers in the last whorl (12 to 14, as compared to seven or eight of *T. tolypa*), and in having a more restricted aperture, which consists of a low arch, rather than the open end of the tube.

It also resembles *Haplophragmoides veleronis* Cushman and McCulloch in the evolute, planispiral test and numerous chambers, but differs in being about one-third as large, more flattened, and in lacking the apertural lip of that species.

Genus HAPLOPHRAGMOIDES
Cushman, 1910
HAPLOPHRAGMOIDES CUSHMANI Loeblich and Tappan, n. sp
Plate 35, figures 4a, 4b

Test free, small, planispiral and involute, thickened, periphery rounded; chambers slightly inflated, increasing in size as added, succeeding chambers reaching almost to the axis of coiling, leaving only a slight umbilicus, about seven chambers in the last whorl; sutures distinct, slightly depressed, straight or slightly curved; wall finely arenaceous, with considerable cement, surface granular in appearance; aperture a low arch at the base of the apertural face of the last-formed chamber.

Greatest diameter of holotype 0.329 mm., least diameter 0.25 mm., greatest thickness 0.194 mm. Other specimens range in greatest diameter from 0.194 mm. to 0.418 mm.

Types.—Holotype (Cushman Coll. no. 45599) and paratypes (Loeblich Coll. no. 1051) from the Paw Paw formation at locality HTL 55, sample 284. Paratypes (Cushman Coll. no. 45619) from the Paw Paw formation at locality HTL 199, sample 736.

Remarks.—This species differs from *Haplophragmium latidorsatum* Bornemann in the smaller size, being about one-half as large, in having more deeply depressed sutures, more lobulate periphery and a more rapid increase in size of the chambers.

It differs from *Haplophragmoides globosa* Lozo, of the Goodland formation, in the slightly larger size, more rapid increase in chamber size, fewer chambers in the final whorl and in having a more inflated final chamber.

Family TEXTULARIIDAE
Subfamily SPIROPLECTAMMININAE
Genus AMMOBACULOIDES Plummer, 1932
AMMOBACULOIDES GAINESVILLENSIS
Loeblich and Tappan, n. sp.
Plate 35, figures 5a–6

Test free, small, early chambers planispiral, later biserial, and finally uniserial, periphery rounded; chambers numerous, low, gradually increasing in size as added, the five to six chambers visible in the last-formed whorl do not reach to the plane of coiling, so that the earliest chamber is visible in the center of the coil; sutures distinct, appearing as clear or dark bands in the coiled portion, slightly depressed in the biserial and uniserial portions, straight in the coiled portion, nearly horizontal in the biserial part, later at an angle, as the biserial chambers tend to become irregularly biserial and then uniserial, sutures straight in uniserial portion; wall finely arenaceous, insoluble in acid, surface granular in appearance; aperture terminal, rounded.

Length of holotype 0.626 mm., greatest breadth of biserial portion 0.186 mm., greatest breadth of uniserial portion 0.136 mm., greatest thickness of biserial portion 0.093 mm., greatest thickness of uniserial portion 0.107 mm. Other specimens range in length from 0.44 mm. to 0.63 mm.

Types.—Holotype (Cushman Coll. no. 45600) and paratypes (Loeblich Coll. no. 1052) from the Denton formation at locality HTL 81, sample 336. Paratype of figure 6 (Cushman Coll. no. 45601) and paratypes (Loeblich Coll. no. 1053) from the Weno formation at locality HTL 22, sample 87. We also have this species in the Paw Paw formation.

Remarks.—This species differs from the *Ammobaculoides* sp. recorded by Tappan (1943) from the Duck Creek formation in the larger size, the Duck Creek figured specimen being about one-half the length of the holotype of the present species, although the Duck Creek form had more chambers. The present species also has a more coarsely arenaceous test and less horizontal sutures.

A. gainesvillensis, n. sp., is very similar in appearance to *A. plummerae* Loeblich from the Pepper formation (Upper Cretaceous), but differs in the slightly larger coil and less

compression of the test, more inflated chambers and more distinctly depressed sutures.

Subfamily TEXTULARIINAE
Genus SIPHOTEXTULARIA Finlay, 1939
SIPHOTEXTULARIA WASHITENSIS
Loeblich and Tappan, n. sp.
Plate 35, figures 9a–11b

Test free, chambers biserially arranged, tapering at the base, periphery truncate, chambers increasing rapidly in size as added; sutures distinct, depressed, nearly straight, but projecting downward at the sides; wall very finely arenaceous, surface smoothly finished; aperture high, slitlike, in the inner face of the last formed chamber, as if tending to become terminal, surrounded by a slight lip.

Length of holotype 0.614 mm., greatest breadth 0.236 mm., greatest thickness 0.122 mm. Other specimens range in length from 0.24 to 0.62 mm.

Types.—Holotype (Cushman Coll. no. 45602) and paratypes (Loeblich Coll. no. 1054) from the Georgetown formation at HTL 96, sample 399. Paratypes of figure 10 (Cushman Coll. no. 45603) and figure 11 (Cushman Coll. no. 45604) from the Fort Worth formation at locality HTL 70, sample 101. We also have this species in samples of Denton and Weno.

Remarks.—This species differs from *Siphotextularia lajollaensis* (Lalicker) in the smaller size, flatter sides and more rapid increase in chamber size. The aperture is also more nearly terminal, and the slit trends parallel to the flat sides of the test, or vertically, rather than paralleling the base of the apertural face of the last chamber.

Genus BIGENERINA d'Orbigny, 1826
BIGENERINA CLAVELLATA Loeblich
and Tappan, n. sp.
Plate 35, figures 7, 8

Test free, small, early portion biserial, later uniserial, periphery rounded; chambers numerous, increasing rapidly in size, short biserial portion consisting of five to nine rounded chambers, uniserial portion generally of greater length, consisting of three to seven chambers, which are rounded in section in well-preserved specimens but generally collapsed in the most elongate specimens, probably due to the conditions of preservation; sutures distinct, depressed, nearly straight; aperture terminal, rounded.

Length of holotype 0.857 mm., greatest breadth of biserial portion 0.129 mm., greatest breadth of uniserial portion 0.236 mm., greatest thickness 0.107 mm. Length of figured paratype 0.403 mm., other specimens range in length from 0.28 to 0.86 mm.

Types.—Holotype (Cushman Coll. no. 45605), paratype of figure 8 (Cushman Coll. no. 45606), and paratypes (Loeblich Coll. no. 1055) from the Weno formation at locality HTL 40, sample 236. Other specimens from the same locality, sample 235, and from the Paw Paw formation at locality HTL 55, samples 282, 283 (paratypes, Loeblich Coll. no. 1056), and 284, and from locality HTL 199, sample 735. The species also occurs in the Denton formation at locality HTL 43, sample 243.

Remarks.—This species resembles *Bigenerina selseyensis* Heron-Allen and Earland in general size and the inflated uniserial chambers. Our species differs in the constriction of the test at the end of the biserial series, in the rapid increase in size of the uniserial chambers, which are also more numerous, and in the less flattened test.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1839
GAUDRYINA BOSQUENSIS Loeblich
and Tappan, n. sp.
Plate 35, figures 12a–13b, text
figures 3A–C

Gaudryina gradata Plummer, 1931 (not Berthelin), Texas Univ. Bull. 3101, p. 136, pl. 8, figs. 12a–b.

Test free, elongate, tapering, the short early triserial portion giving a somewhat bulbous base, the remaining biserial portion almost circular in cross section, due to the thick chambers, as seen in edge view, periphery rounded; early triserially arranged chambers inflated, rounded, early biserial chambers low in height, particularly in the microspheric form, later chambers of comparatively greater height, in some cases the height of the chamber being greater than its breadth; sutures distinct, depressed and straight, and nearly horizontal in the biserial portion; wall very finely arenaceous,

with considerable cement, surface smoothly finished; aperture an arch at the inner margin of the last formed chamber.

Length of holotype 0.893 mm., length of triserial portion 0.194 mm., greatest breadth of test 0.295 mm., greatest thickness of triserial portion 0.202 mm., greatest thickness of biserial portion 0.266 mm. Greatest length of paratype of figure 13, 1.116 mm., length of triserial portion 0.079 mm. Other specimens range in length from 0.382 mm. to 1.15 mm.

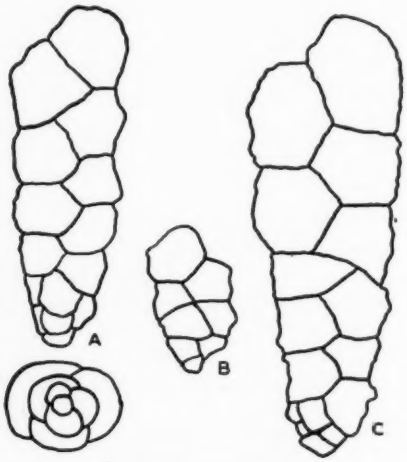


FIG. 3—*Gaudryina bosquensis* Loeblich and Tappan, n. sp. *A*, Side and basal views of holotype; *B*, *C*, paratypes, showing variation in size. All ×53.

Types.—Holotype (Cushman Coll. no 45607) and paratypes of text figures 3B–C (Cushman Coll. no. 45609) and paratypes (Loeblich Coll. no. 1057) from the Main Street equivalent in the Del Rio formation at locality HTL 98, sample 402. Paratype of figure 13 (Cushman Coll. no. 45608) and additional paratypes (Loeblich Coll. no. 1058) from the Paw Paw formation at locality HTL 46, sample 255. The species also occurs in the Weno formation at locality HTL 46, sample 253–254.

Remarks.—This species is undoubtedly that referred by Plummer (1931) to *Gaudryina gradata* Berthelin. In his monograph on the Valvulinidae, Cushman (1937) considered Berthelin's species as a *Dorothia*, stating that the earliest whorl has four to five chambers, the test later becoming triserial, and finally biserial. The Washita species has only a triserial base, is thus a true *Gaudryina*, and distinct from Berthelin's species.

Gaudryina bosquensis, n. sp., also differs from *Dorothia gradata* in the more slender and tapering test and comparatively higher chambers. The triserial portion is often quite reduced, as in the paratype of figure 13.

This species resembles *Gaudryina serrata* Franke in the reduced triangular triserial portion and elongate biserial portion, consisting of inflated chambers, but differs in the slightly larger size and comparatively greater thickness, and in lacking any tendency toward a terminal aperture as is shown in *G. serrata*.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA AESCHRIA Loeblich and Tappan, n. sp.

Plate 35, figures 14a–17

Test free, typically quinqueloculine in plan, elongate, fusiform to sigmoid in outline, periphery rounded; chambers narrow and elongate, somewhat curved, giving a twisted appearance to the test; sutures distinct, depressed; wall calcareous, imperforate, with an outer agglutinated layer; aperture simple, at the end of the chamber, no tooth visible.

Length of holotype 0.324 mm., greatest breadth 0.137 mm., greatest thickness 0.05 mm. Length of other specimens ranges from 0.158 mm. to 0.547 mm.

Types.—Holotype (Cushman Coll. no. 45610) and paratypes (Loeblich Coll. no. 1059) from the Denton formation at HTL 80, sample 330. Paratypes of figure 16 (Cushman Coll. no. 45612) and figure 17 (Cushman Coll. no. 45613) from the Paw Paw formation at locality HTL 46, sample 255. Paratype of figure 15 (Cushman Coll. no. 45611) from the Grayson formation, at locality HTL 1, sample 38. Paratypes (Loeblich Coll. no. 1060) from the Denton formation at locality HTL 81, sample 341 and from the Weno formation (paratypes, Loeblich Coll. no. 1061) at locality HTL 46, sample 252. We also have this species in the Fort Worth and Georgetown formations.

Remarks.—This species resembles *Quinqueloculina lanceolata* Terquem and Berthelin in outline and in the twisted character of

the chambers but differs in lacking the apertural extension of the last chamber and in possessing an arenaceous wall.

QUINQUELOCULINA LIRELLANGULA Loeblich and Tappan, n. sp.
Plate 35, figures 18a–19c

Test free, ovate in outline, triangular in section, periphery keeled; chambers narrow, generally keeled centrally, although in some specimens the angles are bicarinate; wall calcareous, imperforate; aperture simple, rounded, at the end of a short neck, no tooth visible.

Length of holotype 0.454 mm., greatest breadth of test 0.245 mm., thickness from center of opposite side through the third angle 0.158 mm. Other specimens range in length from 0.223 to 0.554 mm.

Types.—Holotype (Cushman Coll. no. 45614) from the Denton formation at locality HTL 80, sample 330; paratype of figure 19 (Cushman Coll. no. 45615) and paratypes (Loeblich Coll. no. 1062) from locality HTL 81, sample 333. We also have this species in the Fort Worth, Weno, Paw Paw and Main Street formations. It is most abundant, however, in the Denton formation.

Remarks.—This species differs from *Quinqueloculina tricarinata* d'Orbigny in the extremely excavated sides, more narrow chambers, smooth and unornamented surface, and smaller size, the present species being about one-third the size of the Recent form. *Quinqueloculina lirellangula* also resembles *Q. nobilis* Karrer in sectional plan and in the excavated sides but differs in lacking any ornamentation, in being more ovate in outline, and in being only about one-half the size of that species.

QUINQUELOCULINA SABELLA Loeblich and Tappan, n. sp.
Plate 35, figures 20a, 20b

Test free, ovate in outline, flattened, typically quinqueloculine in growth; chambers narrow and elongate; sutures distinct, depressed; wall calcareous, with an outer agglutinated layer; aperture rounded, at the end of a short necklike extension of the final chamber.

Length of holotype 0.266 mm., greatest breadth 0.130 mm., greatest thickness 0.065 mm. Length of other specimens ranges from 0.223 to 0.281 mm.

Types.—Holotype (Cushman Coll. no. 45616) and paratypes (Loeblich Coll. no. 1063) from the Grayson formation, at HTL 1, sample 38; the species also occurs in the Weno formation.

Remarks.—This species somewhat resembles *Quinqueloculina yeguaensis* Weinzierl and Applin in general appearance but differs in being about two-thirds the size of that species, in having narrower chambers, a flatter test and a longer necklike extension of the last chamber.

Genus SPIROLOCULINA d'Orbigny, 1826
SPIROLOCULINA OPHIONEA Loeblich and Tappan, n. sp.
Plate 35, figures 21a–c

Test free, lenticular in outline, flattened, slightly thicker centrally, periphery rounded; chambers narrow, a half coil in length; sutures distinct, depressed; wall calcareous, imperforate, with an outer agglutinated layer, aperture simple, at the end of the chamber, no tooth apparent.

Length of holotype 0.274 mm., greatest breadth 0.230 mm., greatest thickness 0.086 mm. Other specimens range from 0.230 to 0.410 mm. in length.

Types.—Holotype (Cushman Coll. no. 45621) and paratypes (Loeblich Coll. no. 1064), from the Weno formation at locality HTL 46, sample 251.

Remarks.—This species somewhat resembles *Spiroloculina penglaiensis* Jacot in the roughly circular outline and flattened test but differs in being about one-fifth as large, possessing fewer chambers and in having an outer agglutinated layer. It also lacks the thin flaring lip of *S. penglaiensis.*

Genus TRILOCULINA d'Orbigny, 1826
TRILOCULINA MEOTICA Loeblich and Tappan, n. sp.
Plate 36, figures 1a–3b

Test free, small, triloculine in development, circular to ovate in outline, the larger specimens being more rotund, periphery rounded; chambers inflated; sutures distinct, depressed; wall calcareous, imperforate; aperture simple, at the end of the chamber, no tooth visible.

Length of holotype 0.194 mm., greatest breadth 0.158 mm., greatest thickness 0.086 mm. Other specimens range in length from 0.108 mm. to 0.202 mm.

Types.—Holotype (Cushman Coll. no. 45628) and paratype (Loeblich Coll. no. 1065) from the Denton formation at HTL 81, sample 341. Paratype of figures 2a–b (Cushman Coll. no. 45630) from the Paw Paw formation at locality HTL 55, sample 281. Paratype of figures 3a–b (Cushman Coll. no. 45629) from the Weno formation, at locality HTL 46, sample 252. Paratypes (Loeblich Coll. no. 1066) from sample 255 at the same locality. We also have this species in the Fort Worth formation at locality HTL 9, sample 203.

Remarks.—This species somewhat resembles *Triloculina inornata* d'Orbigny in general appearance, but differs in being only about one-fifth as large and in lacking the apertural tooth.

Family OPHTHALMIDIIDAE
Subfamily CORNUSPIRINAE
Genus MEANDROSPIRA Loeblich and Tappan, n. gen.

Genotype, *Meandrospira washitensis* Loeblich and Tappan, n. sp.

Test free, composed of proloculum followed by a tubular second chamber, which spirals about the proloculum in short zigzag bends, so that a side view shows numerous loops reaching toward the umbilicus, the loops being formed by the tubular chamber swinging back upon itself frequently; wall calcareous, imperforate; aperture simple, terminal.

This genus is probably a specialized offshoot from *Orthovertella* Cushman and Waters, in which the early variable coils have become regular and developed the zigzag character which is common in many genera of the Ophthalmidiidae. The present genus differs from *Calcitornella* Cushman and Waters and *Calcivertella* Cushman and Waters, both of which have the zigzag tubular second chamber, in being free-living and enrolled, rather than attached to a flat substratum.

MEANDROSPIRA WASHITENSIS Loeblich and Tappan, n. sp
Plate 36, figures 4a–7

Test free, tiny, roughly globular in shape, chambers developing in a zigzag manner, and at the same time enrolled about the proloculum and early portion, succeeding loops of the chamber reaching almost to the axis of coiling but leaving a slight umbilicus, chamber increasing gradually in size, about four loops of the chamber visible on one side of small specimens, as many as seven loops visible on larger specimens; suture between loops distinct, depressed; wall thin, calcareous, imperforate, although like many other members of the Ophthalmidiidae and Miliolidae in these horizons, specimens are filled with a solid cast, and at times the thin chalky wall is eroded, leaving only the clear cast of the interior, which shows the structure of the test, however, and can be easily identified; aperture at the open end of the chamber.

EXPLANATION OF PLATE 36
Miliolidae to Lagenidae

FIGS. *1a–3b*—*Triloculina meotica* Loeblich and Tappan, n. sp. *1*, Holotype, ×76; *2*, *3*, paratypes; ×117. (p. 247)

4a–7—*Meandrospira washitensis* Loeblich and Tappan, n. sp. *4a*, *b*, Paratype, showing irregularly coiled tubular chamber, possibly a reversion to the variable development of *Orthovertella*, ×76; *5a–c*, holotype, ×76; *6*, paratype, ×117; *7*, paratype; ×76. (p. 248)

8–13—*Nodophthalmidium pyriformis* (Tappan). *8*, *10*, Hypotypes of two chambers, with the porcellanous and arenaceous coating intact; *9*, *12a–b*, *13*, internal casts of the initial coiled portion, showing proloculum and tubular second chamber beginning to uncoil; *11*, internal cast of uniserial chamber, with a portion of the neck of the previous chamber attached at its base. All ×53. (p. 249)

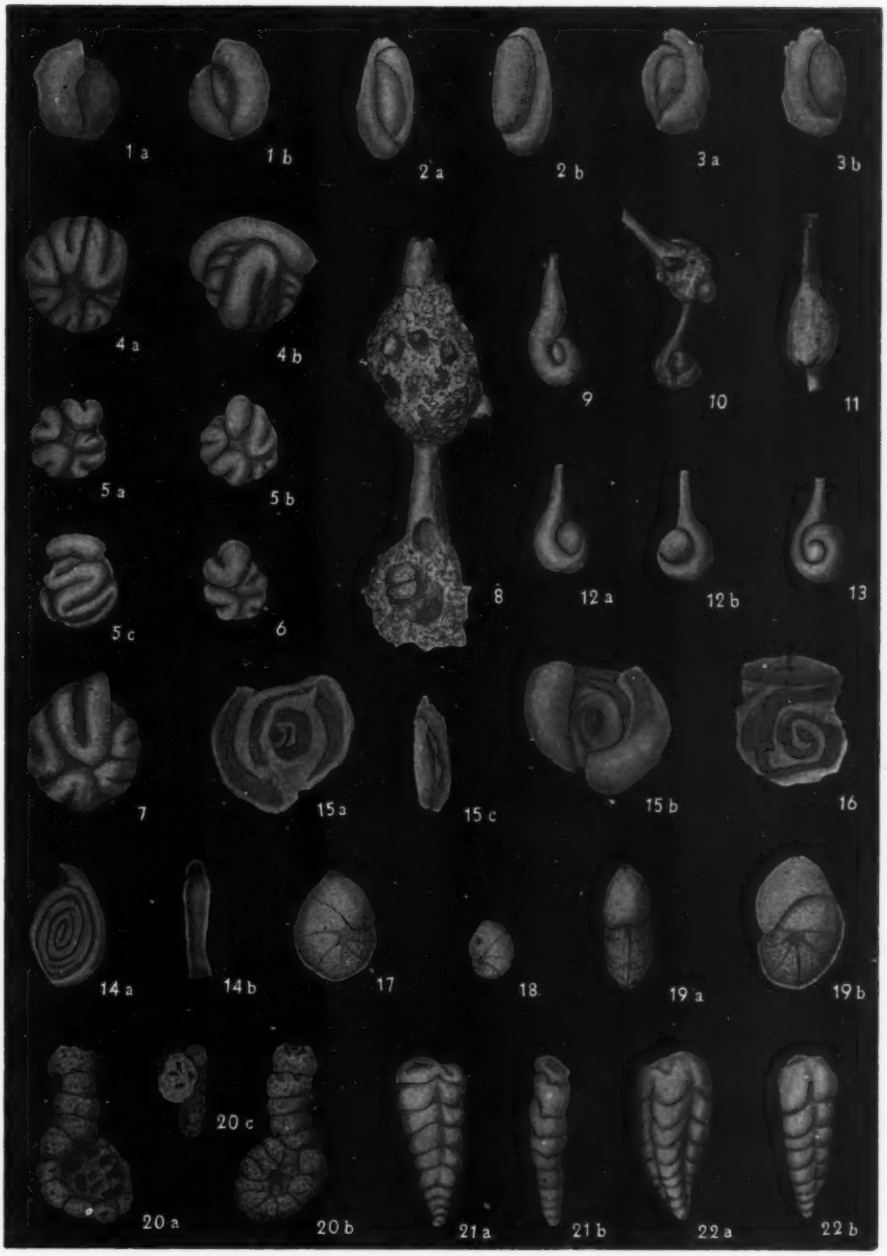
14a–b—*Ophthalmidium amplectens* Loeblich and Tappan, n. sp. *14a*, Side view of holotype; *14b*, edge view; ×76. (p. 250)

15a–16—*Ophthalmina scariosa* Loeblich and Tappan, n. sp. *15a*, Side view of holotype; *15b*, opposite side, showing attachment scar; ×82; *15c*, edge view, ×76; *16*, paratype, showing last chamber with zigzag tendency as in *Meandroloculina;* ×76. (p. 251)

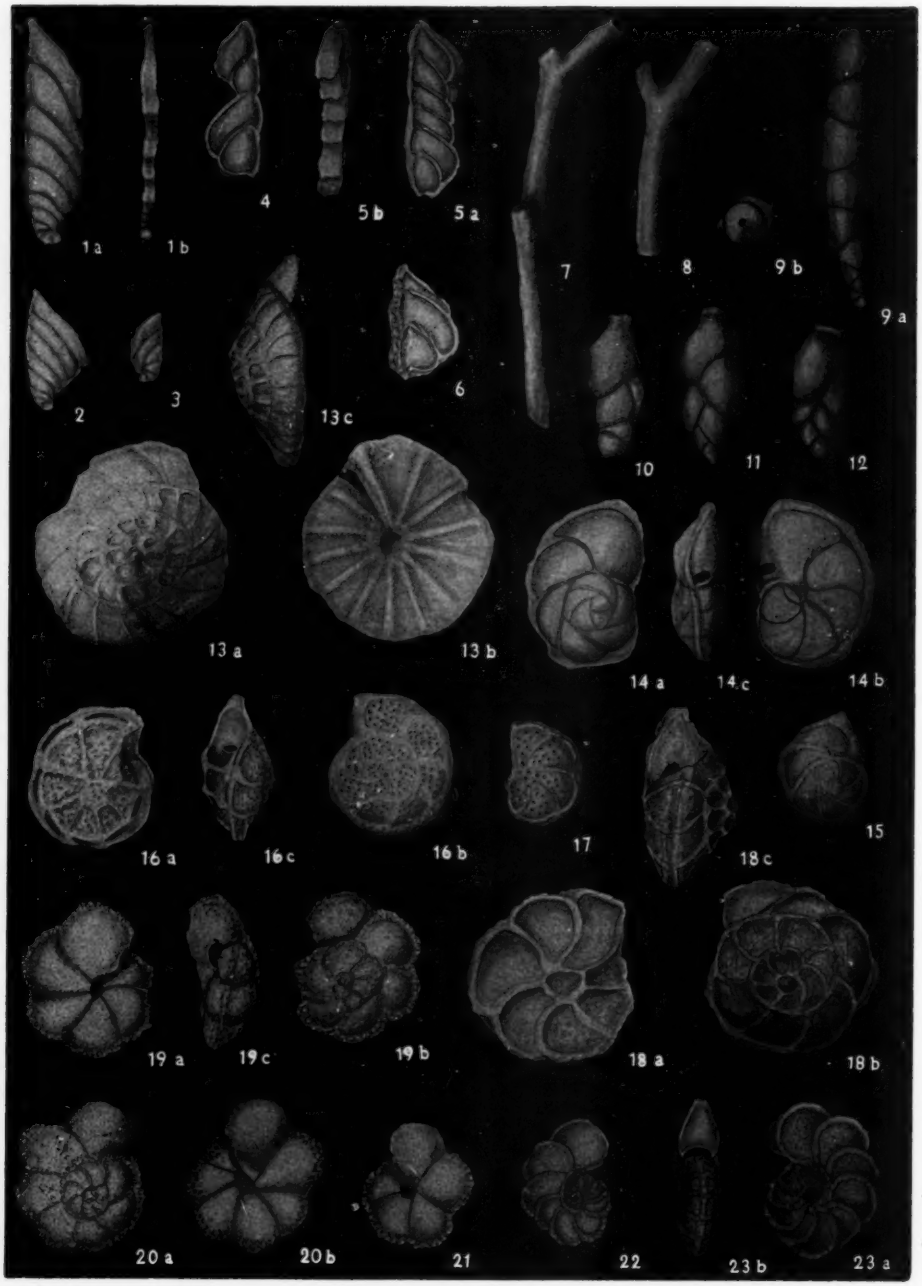
17–19b—*Marginulina sestrona* Loeblich and Tappan, n. sp. *17*, *18*, Paratypes; *19a*, edge view of holotype; *19b*, side view; ×35. (p. 252)

20a–c—*Acruliammina longa* (Tappan). *20a*, Hypotype, showing attachment of coiled portion and free growing uniserial portion; *20b*, dorsal view; *20c*, apertural view; ×10. (p. 252)

21a–22b—*Lingulina aeolia* Loeblich and Tappan, n. sp. *21a*, Side view of holotype; *21b*, edge view; *22a*, side view of paratype showing third angle; *22b*, edge view; ×35. (p. 253)



Loeblich and Tappan, Washita (Comanche) Foraminifera



Loeblich and Tappan, Washita (Comanche) Foraminifera

Greatest diameter of holotype 0.173 mm., least diameter 0.144 mm., greatest thickness 0.151 mm. Greatest diameter of paratype of figure 7, 0.216 mm. Other specimens range in diameter from 0.101 to 0.259 mm.

Types.—Holotype (Cushman Coll. no. 45631) and paratypes (Loeblich Coll. no. 1067) from the Denton formation at locality HTL 43, sample 243. Paratype of figures 4a–b (Cushman Coll. no. 45632) from the Duck Creek formation at locality HTL 60, sample 303; paratype of figure 6 (Cushman Coll. no. 45633) and paratypes (Loeblich Coll. no. 1068) from the Weno formation, at locality HTL 176, sample 687, and of figure 7 (Cushman Coll. no. 45634) from the Paw Paw formation at locality HTL 55, sample 284. We have this species from every surface Washita formation, from the Duck Creek through the Grayson. It is most abundant in the Duck Creek formation, although larger and better-developed specimens are found in the middle Washita, the species becoming rare in the Main Street and Grayson formations of the upper Washita. It also occurs rarely in the underlying Kiamichi formation of the Fredericksburg group, paratypes in our collection being from sample 437 (Loeblich Coll. no. 1069), from about 3 feet below the Duck Creek contact; from sample 436, about 5½ feet below the contact; and sample 432, which is from 17 feet below the contact, all at locality HTL 104, a high, north-facing slope on the south bank of the Red River, cleared by excavation at the site of the Denison Dam, north of Denison, Grayson County, Texas. This excavation was made during construction of the Dam, now forming Lake Texhoma, and the slope has now been covered and grassed over. Our collections were made in July, 1940.

Remarks.—This species is entirely unlike any foraminifer described. It differs from *Orthovertella protea* Cushman and Waters, the genotype of the genus from which *Meandrospira* is thought to have arisen, in having developed a very regular plan of coiling, with the tubular chamber zigzagging back and forth around the axis of coiling. *Orthovertella protea* has a close-coiled young stage, but the coils vary in plane and the tubular chamber later uncoils, while no specimens of *Meandrospira* have been found showing any tendency to uncoil.

Subfamily NODOPHTHALMIDIINAE
Genus NODOPHTHALMIDIUM Macfadyen, 1939

NODOPHTHALMIDIUM PYRIFORMIS (Tappan)
Plate 36, figures 8–13

Lagenammina pyriformis TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 94, pl. 14, figs. 1a–2b.

Lagenammina pyriformis TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 479, pl. 77, figs. 1a–2b.

Test free or possibly attached to seaweeds so that the attachment is not preserved, early portion coiled, later uniserial

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EXPLANATION OF PLATE 37
Lagenidae to Anomalinidae

FIGS. *1a–3—Vaginulina leptoteicha* Loeblich and Tappan, n. sp. *1a*, Side view of holotype; *1b*, edge view; *2*, *3*, side views of paratypes; ×35. (p. 253)

4–6—Vaginulina acricula Loeblich and Tappan, n. sp. *4*, *6*, Side views of paratypes; *5a*, side view of holotype; *5b*, edge view; ×35. (p. 253)

7–8—Ramulina abscissa Loeblich and Tappan, n. sp. *7*, Holotype; *8*, paratype; ×53. (p. 254)

9a–b—Nodosarella cuneata Loeblich and Tappan, n. sp. *9a*, Side view of holotype; *9b*, top view; ×53. (p. 255)

10–12—Eouvigerina laxistoma Loeblich and Tappan, n. sp. *10*, Paratype, ×76; *11*, holotype; ×117; *12*, paratype; ×117. (p. 254)

13a–c—Eponides acria Loeblich and Tappan, n. sp. *13a*, Dorsal view of holotype; *13b*, ventral view; *13c*, edge view; ×117. (p. 255)

14a–15—Eponides stilbius Loeblich and Tappan, n. sp. *14a*, Dorsal view of holotype; *14b*, ventral view; *14c*, edge view; *15*, dorsal view of paratype; ×53. (p. 255)

16a–17—Epistomina lacunosa Loeblich and Tappan, n. sp. *16a*, Ventral view of holotype; *16b*, dorsal view; *16c*, edge view; *17*, dorsal view of paratype; ×53. (p. 256)

18a–c—Epistomina scaphiolocula Loeblich and Tappan, n. sp. *18a*, Ventral view of holotype; *18b*, dorsal view; *18c*, edge view; ×46. (p. 256)

19a–21—Globorotalia marginaculeata Loeblich and Tappan, n. sp. *19a*, Ventral view of holotype; *19b*, dorsal view; *19c*, edge view; *20*, *21*, paratypes; ×53. (p. 257)

22–23b—Planomalina apsidostroba Loeblich and Tappan, n. sp. *22*, Paratype; *23a*, side view of holotype; *23b*, edge view; ×46. (p. 258)

and rectilinear; chambers numerous, consisting of a globular proloculum followed by a coiled tubular second chamber, which coils from three quarters to completely around the proloculum, then turns out to begin the rectilinear portion, uniserial chambers pyriform in outline, with long, slender, tapering necks, which are fragile and frequently broken, so that commonly only isolated chambers are found, the necks of preceding chambers may remain attached at the base of the later chamber, and then resemble an apical spine, as they were considered to be in the original description of the species as *Lagenammina;* sutures distinct between the uniserial chambers because of the constriction into the long slender necks, but indistinct in the early coiled portion, where an arenaceous coating completely obscures the coiled structure, which is apparent, however, in casts of the interior, as in figures 9, 12 and 13; wall calcareous, porcellanous, with an arenaceous coating, in some specimens the coating is broken away, leaving an internal cast, which clearly shows the coiled arrangement of the early chambers as well as the pyriform shape of the later ones (figure 11) and which may be obtained from any specimen by breaking away the arenaceous and porcellanous covering; aperture terminal, rounded.

Length of hypotype of figure 8, 1.094 mm., greatest breadth of coiled portion 0.31 mm., greatest breadth of second chamber 0.31 mm. Length of proloculum and tubular second chamber ranges from 0.209 mm. to 0.562 mm.; length of pyriform chambers ranges from 0.288 mm. to 1.08 mm. No specimens have been obtained with more than two uniserial chambers, but this is undoubtedly due to the fragile nature of the test, rather than short original development, as even those of two chambers still connected are extremely rare.

Types.—Hypotypes of figure 8 (Cushman Coll. no. 45622), figure 10 (Cushman Coll. no. 45625) and figure 11 (Cushman Coll. no. 45627) and hypotypes (Loeblich Coll. no. 1070), all from the Paw Paw formation at locality HTL 199, sample 736; hypotype of figure 9 (Cushman Coll. no. 45623) and of figure 12 (Cushman Coll. no. 45624) from the Grayson formation at locality HTL 103, sample 419; hypotype of figure 13 (Cushman Coll. no. 45626) from the Denton formation at locality HTL 43, sample 243. We have this species abundantly represented in the Duck Creek, Fort Worth, Denton, Weno, Paw Paw and Grayson formations, although specimens with more than one chamber are rare, the majority representing isolated chambers.

Remarks.—Isolated chambers of this species were described by Tappan (1940) as *Lagenammina pyriformis* and the neck of an earlier chamber attached at the base of the specimens was described as an apical spine (see figure 11) due to its solid condition. It is now shown that it was in reality part of the solid cast of the chambers, and because of the multilocular character the species cannot belong to *Lagenammina.*

Casts of this species very closely resemble *Nodophthalmidium simplex* Cushman and Todd, from which it differs in being approximately twice as large, and in developing an arenaceous coating.

It somewhat resembles *Nubecularia nodulosa* Chapman in general size and appearance, but differs in possessing the arenacous coating and early coiled portion. It also resembles in some characters the Recent miliolid genus *Nubeculina* Cushman, and in particular, the genotype, *N. divaricata* (H. B. Brady), but lacks the milioline beginning and the lip and teeth surrounding the aperture. It is most like the genus *Nodophthalmidium* Macfadyen, in plan and arrangement of chambers, in the imperforate wall and simple terminal aperture. It differs in possessing the arenaceous coating, which has heretofore not been recorded in species of this family, although it is frequent in members of the imperforate family Miliolidae. However, because of the early planispiral, *Cornuspira*-like development, rather than a milioline beginning, the species is referred to *Nodophthalmidium.* This genus has heretofore been recorded only from the Tertiary and Recent, and the geologic range is here extended downward to include the Lower Cretaceous.

Subfamily OPHTHALMIDIINAE
Genus OPHTHALMIDIUM Zwingli and Kübler, 1870

OPHTHALMIDIUM AMPLECTENS Loeblich and Tappan, n. sp.
Plate 36, figures 14a, 14b

Test free, small, planispiral, periphery

truncate; proloculum followed by two chambers in each coil, chambers narrow; sutures distinct; wall calcareous, imperforate; aperture simple, at the open end of the chamber.

Length of holotype 0.238 mm., greatest breadth 0.144 mm., greatest thickness 0.05 mm.

Types.—Holotype (Cushman Coll. no. 45635) and paratypes (Loeblich Coll. no. 1071) from the Denton formation, at locality HTL 81, sample 341. This species also occurs in the Paw Paw formation, at locality HTL 55, sample 283.

Remarks.—This species differs from *Ophthalmidium acutimargo* (H. B. Brady) in being about one-fourth as large, with comparatively greater thickness, truncate periphery and nearly tubular chambers. It lacks the neck and lip and carinate periphery of *O. acutimargo.*

It differs from *O. minima* Tappan, from the Duck Creek formation, in being about one-third as large, more ovate in outline, rather than acuminate, in being comparatively thicker, and in possessing a distinctly truncate periphery.

Genus OPHTHALMINA Rhumbler, 1936

OPHTHALMINA SCARIOSA Loeblich and Tappan, n. sp.

Plate 36, figures 15a–16

Ophthalmidium adhaerens TAPPAN, 1943 (in part), Jour. Paleontology, vol. 17, no. 5, p. 491, pl. 78, fig. 35 (not fig. 34).

Test attached, possibly to seaweeds, as specimens occur free although showing attachment scars, planispiral, compressed; consisting of a globular proloculum followed by a planispiral tube of almost a complete coil, later chambers of lesser length, with from two to two and one-half chambers to a whorl, chambers loose-coiled, intermediate area filled by a thin plate, chambers tapering slightly toward the aperture, thicker at the base; sutures distinct, depressed; wall calcareous, imperforate; aperture at the open end of the chamber, rounded.

Length of holotype 0.223 mm., breadth 0.259 mm., thickness 0.058 mm. Greatest diameter of paratype 0.382 mm., least diameter 0.209mm.

Types.—Holotype (Cushman Coll. no. 45636) from the Denton formation at HTL 81, sample 333. Paratype of figure 16 (Cushman Coll. no. 45637) and additional paratypes (Loeblich Coll. no. 1072) from the same locality, sample 341.

Remarks.—The specimen figured and described as a paratype of *Ophthalmidium adhaerens* Tappan belongs to this species. *Ophthalmidium adhaerens* also should be referred to *Ophthalmina* because of its attached habit. *Ophthalmina scariosa*, n. sp., differs from *O. adhaerens* (Tappan) in the smaller size, being only about one-half the diameter of *O. adhaerens*, and in being flattened, while *O. adhaerens* becomes much thicker, particularly the last chamber, which is almost triangular in section. *O. adhaerens* also has a distinct neck, while *O. scariosa* has an aperture at the end of the last chamber, which is not greatly constricted.

The paratype in figure 16 shows a tendency toward the characters of *Meandroloculina*, as does the specimen figured by Tappan (1943, pl. 78, fig. 35), in that the last chamber has turned back on those preceding, as in the zigzag later chambers of *Meandroloculina*. This zigzag development is also shown in *Ophthalmidium nubeculariformis* Haeusler, which somewhat resembles the present species also in the shape of the chambers, which are widest at the base, tapering to the aperture, and in possessing a flat plate between the chambers and an irregular outline. The present species differs in having fewer chambers to the coil and in being attached.

Ophthalmina scariosa, n. sp., is also somewhat similar to *Ophthalmidium tumidulum* Brady, but differs in being of smaller size, in possessing two and one-half chambers in the last whorl, while *O. tumidulum* has only one and one-half to two. The total number of chambers is fewer in the present species, in specimens of comparable size, and the test has a more angular outline, and was originally attached.

The present species differs from *Ophthalmina kilianensis* Rhumbler in being about one-half as large, and in having two and one-half chambers to a coil in the later stages rather than only two. The test also has a more angular outline.

Ophthalmina has been known only from the Recent, the geologic range now is extended downward to include the Lower Cretaceous.

Family PLACOPSILINIDAE
Subfamily PLACOPSILININAE
Genus ACRULIAMMINA Loeblich and Tappan, n. gen.

Genotype, *Acruliammina longa* (Tappan).

Test attached, at least in the early portion; chambers numerous, at first close-coiled, later uncoiling, only a few chambers of the coiled portion may be attached or all of the coiled portion and much of the uniserial portion may be attached, the later portion of the test usually growing free from the attachment, the uniserial part then becoming cylindrical; wall arenaceous; aperture terminal, a single low slit at the attachment in the early stages, later divided by a median septum and finally cribrate.

This genus probably arose from *Placopsilina* by the development of a multiple aperture.

In addition to the genotype, it is probable that *Lituola serpula* Tappan, described from the Duck Creek formation, also belongs to the genus *Acruliammina*, as the holotype of that species shows what is probably an attachment scar on one side of the coiled portion. It also possesses a free uniserial portion with a cribrate aperture.

ACRULIAMMINA LONGA (Tappan)
Plate 36, figures 20a–c

Placopsilina longa TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 100, pl. 15, figs. 9a–10.
Haplostiche texana TAPPAN, 1943 (not *Nodosaria texana* CONRAD, 1857), Jour. Paleontology, vol. 17, no. 5, p. 480, pl. 77, fig. 5.
Placopsilina longa, TAPPAN, 1943, Jour. Paleontology, vol. 17, no. 5, p. 493, pl. 79, figs. 8–9c.
Placopsilina longa Tappan. LOZO, 1944, Am. Midland Naturalist, vol. 31, no. 3, p. 552, pl. 3, fig. 3, text figure 20.

Test large, elongate, attached in the early portion, later growing upward from the attachment; chambers numerous, at first planispirally arranged, with five to 11 chambers in a whorl, the bulbous proloculum sometimes protruding from the center, later uncoiling and becoming uniserial, with the uniserial portion of four to 15 chambers usually growing free of the attachment, at least in part, and in the specimen shown in figure 20, the last whorl of the coiled portion is also free from the attachment, however there may be only one whorl in the coiled portion as in the holotype, direction of growth frequently modified by the material to which the test is attached; sutures distinct, depressed; wall thick, coarsely arenaceous, with considerable cement; aperture terminal, a slit at the attachment in the early attached stages, later may be divided by a median septum and when the test grows free of the attachment the aperture becomes rounded and in many specimens becomes cribrate.

Length of figured hypotype 2.462 mm., greatest breadth of coiled portion 1.418 mm., greatest breadth of uniserial portion 0.691 mm. Other specimens are as much as 5.56 mm. in length.

Types.—Figured hypotype (Cushman Coll. no. 45638) and hypotypes (Loeblich Coll. no. 1073) from the Paw Paw formation at locality HTL 55, sample 282; hypotype (Cushman Coll. no. 45639) from the Duck Creek formation, at locality HTL 13, sample 121. The species occurs in every formation of the Washita formation, as well as in the underlying Kiamichi.

Remarks.—The specimens referred to *Haplostiche texana* (Conrad) by Tappan (1943) were the free uniserial portions of specimens of this species, which had broken from the coiled and attached portion. They differ from Conrad's species in the lower chambers, flatter apertural region, and in lacking the labyrinthic interior and produced neck of that species. Complete specimens also show the early coil and the attached character.

Acruliammina longa (Tappan) differs from *A. serpula* (Tappan) in having depressed and much more distinct sutures and a larger area of attachment.

Family LAGENIDAE
Subfamily NODOSARIINAE
Genus MARGINULINA d'Orbigny, 1826
MARGINULINA SESTRONA Loeblich and Tappan, n. sp.
Plate 36, figures 17–19b

Test free, inflated, early portion close-coiled, last chamber becoming uncoiled, periphery with a slight keel; chambers numerous, about six in the last whorl, increasing rapidly in size; sutures distinct, appearing darker than the chambers, but not depressed; wall calcareous, with unusually coarse perforations, no other ornamentation;

aperture radiate, at the peripheral angle.

Greatest diameter of holotype 0.511 mm., least diameter 0.302 mm., greatest thickness 0.216 mm. Other specimens range from 0.13 to 0.51 mm. in length.

Types.—Holotype (Cushman Coll. no. 45640) and paratypes of figure 17 (Cushman Coll. no. 45641) and figure 18 (Cushman Coll. no. 45642) and additional paratypes (Loeblich Coll. no. 1074) all from the Paw Paw formation at locality HTL 55, sample 282. Paratypes also from the Paw Paw formation at locality HTL 46, sample 257.

Remarks.—This species also somewhat resembles *Marginulina lamperti* (Andreae) in general appearance and in possessing the large perforations, but is slightly larger, has a more enrolled early portion and fewer uncoiled chambers, and a less well developed keel.

Genus LINGULINA d'Orbigny, 1826

LINGULINA AEOLIA Loeblich and Tappan, n. sp.

Plate 36, figures 21a, 22b

Test free, large, uniserial, compressed, tapering at the base, periphery rounded; chambers numerous, low and broad, increasing rapidly in breadth from the globular proloculum, chambers bending downward at the margins, higher in the center, in the figured paratype the later chambers show a tendency to develop a third angle in the center of one side; sutures distinct, depressed, chevron-shaped; wall calcareous, finely perforate, smooth; aperture terminal, elongate.

Length of holotype 0.684 mm., greatest breadth 0.31 mm., greatest thickness 0.151 mm.

Types.—Holotype (Cushman Coll. no. 45643) and figured paratype (Cushman Coll. no. 45644) from the Paw Paw formation at locality HTL 46, sample 256. Paratypes (Loeblich Coll. no. 1075) from the Weno formation at locality HTL 22, sample 87.

Remarks.—This species somewhat resembles *Lingulina ovalis* Schwager, but differs in the more regular increase in chamber size, lower and wider chambers, and in the tendency to develop a third angle, as seen in the paratype.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA ACRICULA Loeblich and Tappan, n. sp.

Plate 37, figures 4–6

Test free, compressed, narrow, with truncate periphery, giving a quadrate cross-section, all angles keeled, dorsal margin straight, ventral margin indented at the sutures, margins of the test approximately parallel from the second chamber upward; chambers numerous, low, higher at the dorsal margin, extending downward ventrally, sides flat, somewhat depressed below the level of the sutures, proloculum ovate, inflated, with a basal projection at the dorsal side; sutures distinct, limbate, raised, higher dorsally; wall calcareous, finely perforate, surface smooth, with no ornamentation other than the marginal keels and elevated sutures and apical projection of the proloculum; aperture radiate, at the dorsal angle.

Length of holotype 0.727 mm., greatest breadth 0.245 mm., greatest thickness 0.122 mm. Length of other specimens ranges from 0.259 mm. (single chamber) to 1.159. mm.

Types.—Holotype (Cushman Coll. no. 45648) and paratype of figure 4 (Cushman Coll. no. 45649), and of figure 6 (Cushman Coll. no. 45650) and additional paratypes (Loeblich Coll. no. 1076), all from the Weno formation at locality HTL 47, sample 262. Paratypes (Loeblich Coll. no. 1077) from the Fort Worth formation at locality HTL 9, sample 203. This species is abundant in the Georgetown, Fort Worth, Denton and Weno formations.

Remarks.—This species somewhat resembles *Vaginulina recta* Reuss, which also occurs in the Washita formations, but differs in the distinctly pointed tip of the proloculum, giving a sinuate basal margin to the test, while *Vaginulina recta* has a globular proloculum, lacking ornamentation. The present species also lacks the distinct neck of *V. recta*.

VAGINULINA LEPTOTEICHA Loeblich and Tappan, n. sp.

Plate 37, figures 1a–3

Test free, elongate, flattened, sides parallel, dorsal margin straight, ventral margin indented by sutures, periphery truncate,

angles keeled; chambers numerous, low, increasing rapidly in breadth after the globular proloculum, later chambers broad and low, sides flat; sutures distinct, very slightly depressed, nearly straight, highest dorsally; wall calcareous, finely perforate, surface smooth; aperture radiate, at the peripheral angle, which is produced into a short neck.

Length of holotype 0.914 mm., greatest breadth 0.245 mm., greatest thickness 0.079 mm. Length of other specimens ranges from 0.302 to 1.022 mm.

Types.—Holotype (Cushman Coll. no. 45645) and paratype of figure 2 (Cushman Coll. no. 45646) and figure 3 (Cushman Coll. no. 45647), and paratypes (Loeblich Coll. no. 1078) all from the Paw Paw formation at locality HTL 55, sample 284. Paratypes (Loeblich Coll. no. 1079) from the Paw Paw formation at locality HTL 46, sample 256. This species is very common in the Weno and Paw Paw formations, rare in the Denton and Georgetown, and has not yet been recorded elsewhere.

Remarks.—This species differs from *Vaginulina kochii* Roemer, with which it occurs, in being about one-half as large, in having more of a coiled base, and in being thinner. The extremely flat test is of nearly equal thickness throughout its length, with almost no increase in thickness after the proloculum.

Family POLYMORPHINIDAE
Subfamily RAMULININAE
Genus RAMULINA Rupert Jones, 1875
RAMULINA ABSCISSA Loeblich and Tappan, n. sp.
Plate 37, figures 7, 8

Test free, consisting of an elongate tube, of nearly equal diameter throughout, and branching dichotomously, the plane of each successive branching at right angles to the plane of the previous branching, specimens generally consisting of fragments of the original, due to its great length and fragile character; wall calcareous, finely perforate, surface smooth; aperture at the open ends of the tube.

Length of holotype 1.087 mm., diameter of tubular chamber ranges from 0.065 mm. to 0.072 mm., angle of branching about 40°. Length of other specimens up to 1.181 mm.

Types.—Holotype (Cushman Coll. no. 45651) and figured paratype (Cushman Coll. no. 45652) and additional paratypes (Loeblich Coll. no. 1080) all from the Paw Paw formation at locality HTL 55, sample 282. We have this species in every outcropping formation of the Washita group, although it is most common in the Weno, Paw Paw and Main Street formations.

Remarks.—This species differs from *R. globulifera* H. B. Brady in lacking the bulbous chambers and spinose wall of that species, and in consisting only of narrow, smooth-surfaced, elongate tubes with a regular manner of branching.

Family HETEROHELICIDAE
Subfamily EOUVIGERININAE
Genus EOUVIGERINA Cushman, 1926
EOUVIGERINA LAXISTOMA Loeblich and Tappan, n. sp.
Plate 37, figures 10–12

Test free, tiny, biserial at the base, later irregularly triserial; chambers inflated, increasing rapidly in size as added; sutures distinct, depressed in later portion; wall calcareous, finely perforate; aperture terminal, rounded, with a definite and quite thick neck, and slightly phialine lip.

Length of holotype 0.194 mm., greatest breadth 0.072 mm. Length of other specimens varies from 0.137 to 0.266 mm.

Types.—Holotype (Cushman Coll. no. 45653) and paratype of figure 12 (Cushman Coll. no. 45655) and paratypes (Loeblich Coll., no. 1081) from the Grayson formation at locality HTL 1, sample 38. Paratype of figure 10 (Cushman Coll. no. 45654) and paratypes (Loeblich Coll. no. 1082) from the Paw Paw formation at locality HTL 46, sample 255. We have this species in the Weno, Paw Paw, Main Street and Grayson formations.

Remarks.—This species extends the geologic range of the genus *Eouvigerina* into the Lower Cretaceous, as it had not previously been recorded earlier than Upper Cretaceous.

This species is somewhat similar in size and in having smooth, rounded chambers to *Eouvigerina austinana* Cushman, but it differs in having a more tapering base, somewhat higher and more inflated later chambers, and more deeply depressed sutures. The aperture is comparatively wide and there is no trace of microspheric coiling in the present species.

Family ELLIPSOIDINIDAE
Genus NODOSARELLA Rzehak, 1895
NODOSARELLA CUNEATA Loeblich and Tappan, n. sp.
Plate 37, figures 9a–b

Test free, elongate, slightly arcuate, early portion showing biserial tendency, later becoming uniserial, rounded in cross section; chambers numerous, early ones cuneate, showing the biserial origin, later chambers higher and more typically uniserial; sutures straight, distinct, depressed; wall calcareous finely perforate, surface smooth; aperture subterminal, rounded.

Length of holotype 0.756 mm., greatest breadth 0.115 mm., other specimens range from 0.25 to 0.76 mm. in length.

Types.—Holotype (Cushman Coll. no. 45656) and paratypes (Loeblich Coll. no. 1083) from the Main Street formation at locality HTL 97, sample 401, the species being particularly abundant here. We also record this species as rare in the Main Street formation at locality HTL 36, sample 230.

Remarks.—This species is most similar to *Nodosarella gracillima* Cushman, but differs in the smaller size, better developed biserial portion, and in possessing wedge-shaped uniserial chambers throughout its length. In *N. gracillima* the later chambers become more nodosarian, with straight, horizontal sutures.

Nodosarella cuneata, n. sp., is more similar in early development to *N. primitiva* Cushman, but differs from that species in the more elongate and tapering test, and more numerous chambers.

Family ROTALIIDAE
Subfamily ROTALIINAE
Genus EPONIDES Montfort, 1808
EPONIDES ACRIA Loeblich and Tappan, n. sp.
Plate 37, figures 13a–c

Test free, small, trochoid, conical, ventrally umbilicate, all chambers visible dorsally, only those of the last whorl seen on the flattened ventral side; chambers numerous, nine to 14 chambers in the last whorl, two to three convolutions visible; sutures distinct, curved backward on the dorsal side, straight and radiating from the umbilicus on the ventral side, somewhat thickened; wall calcareous, finely perforate, surface smooth; aperture in the face of the last chamber, near the periphery on the ventral side.

Greatest diameter of holotype 0.245 mm., least diameter 0.223 mm., greatest thickness 0.086 mm. Other specimens range from 0.180 mm. to 0.259 mm. in greatest diameter.

Types.—Holotype (Cushman Coll. no. 45657) and paratypes (Loeblich Coll. no. 1084) from the Paw Paw formation at locality HTL 65, sample 95; paratypes (Cushman Coll. no. 45620) from the Georgetown formation at locality HTL 96, sample 396. We also have this species from the Grayson (Del Rio) formation at locality HTL 90, sample 369.

Remarks.—This species resembles *Eponides patelliformis* Stadnichenko in dorsal view, both having about the same number of convolutions and the same number of chambers in the last whorl, with sutures oblique dorsally and radiate ventrally. It differs in lacking the filled umbilicus and peripheral keel, in being more flattened ventrally and in having thickened sutures.

EPONIDES STILBIUS Loeblich and Tappan, n. sp.
Plate 37, figures 14a–15

Test free, trochoid, auriculate in outline, all chambers visible dorsally, only those of the last-formed whorl visible ventrally, slight depression in the umbilical area of the flattened ventral side, periphery with a narrow but not sharp keel; chambers numerous, five to six in the last-formed whorl, increasing in size as added; sutures limbate, slightly raised on the dorsal side, slightly depressed ventrally, sutures curved, distinct in the later portion, indistinct in the early part; wall calcareous, highly polished in appearance, very finely perforate; aperture large and rounded, at the base of the ventral side of the chamber, just ventral from the peripheral keel.

Greatest diameter of holotype 0.439 mm., least diameter 0.306 mm., greatest thickness 0.151 mm., greatest diameter of other specimens between 0.202 mm. and 0.454 mm.

Types.—Holotype (Cushman Coll. no. 45658), figured paratype (Cushman Coll. no. 45659) and paratypes (Loeblich Coll. no.

1085) from the Denton formation at locality HTL 81, sample 337. This species also occurs at the same locality, in sample 339.

Remarks.—This species resembles *Eponides cubensis* Palmer and Bermudez in the similar size and in possessing the broad limbate sutures, approximately the same number of chambers in the final whorl, and in having a highly polished surface. *E. stilbius*, n. sp., differs in having a more auriculate outline, a flatter ventral side, in the sutures being more curved ventrally, in possessing a wider peripheral keel and rounded and more restricted aperture, and in lacking the coarse perforations.

The large rounded aperture of this species suggests a tendency toward the apertural characters of *Epistomina*.

Subfamily SIPHONININAE
Genus EPISTOMINA Terquem, 1883
EPISTOMINA LACUNOSA Loeblich and Tappan, n. sp.
Plate 37, figures 16a–17

Test free, trochoid, biconvex, periphery keeled, umbilical area filled; chambers numerous, increasing in size as added, six to seven in the last whorl; sutures raised and limbate, particularly on the ventral side, occasionally somewhat nodose in appearance, sutures curved backward on the dorsal side, straight ventrally; wall calcareous, very coarsely perforate, surface ornamented by the limbate and occasionally nodose raised sutures, and the large pitlike perforations; aperture oval in outline, in the central part of the apertural face, just ventral from the peripheral keel, supplementary apertural slits at the ventral side of the peripheral margin, distinct, usually filled with shell material.

Greatest diameter of holotype 0.403 mm., least diameter 0.324 mm., greatest thickness 0.194 mm. Other specimens range in greatest diameter from 0.180 to 0.403 mm.

Types.—Holotype (Cushman Coll. no. 45660), figured paratype (Cushman Coll. no. 45661) and paratypes (Loeblich Coll. no. 1086) from the Denton formation at locality HTL 81, sample 337. This species occurs abundantly in the Denton formation, and we also have it in the Weno and Paw Paw formations.

Remarks.—This species resembles *Pulvinulina pondensis* Chapman in the number of convolutions, number of chambers in the last whorl, backward-curving limbate sutures, and large pits on the surface of the test. It differs in being less than one-half as large, in having straighter sutures ventrally, and in these being nodose, and in possessing the peripheral slits typical of *Epistomina*.

The present species differs from *Epistomina charlottae* Vieaux, which also occurs in the Denton formation, in possessing the large surface pits, while *E. charlottae* has small nodes on the surface of the chambers, and in having less elevated sutures, particularly dorsally, and in lacking the reticulate umbilical area, which is characteristic of *E. charlottae*.

EPISTOMINA SCAPHIOLOCULA Loeblich and Tappan, n. sp.
Plate 37, figures 18a–c

Test free, trochoid, biconvex, all chambers visible on the dorsal side, only those of the last whorl visible ventrally, periphery with a double keel; chambers numerous, six to seven in the last whorl; sutures distinct, raised and thickened, curved backward; wall calcareous, coarsely perforate, giving a granulose appearance to the surface; aperture a low arch at the base of the apertural face, a slight distance ventrally from the periphery.

Greatest diameter of holotype 0.576 mm., least diameter 0.490 mm., greatest thickness 0.310 mm. Other specimens vary in diameter from 0.252 to 0.576 mm.

Types.—Holotype (Cushman Coll. no. 45662) and paratypes (Loeblich Coll. no. 1087) from the Paw Paw formation at locality HTL 46, sample 256. We have this species also from the Fort Worth, Denton and Weno formations.

Remarks.—This species differs from *Epistomina lenticularia* Tappan, of the Duck Creek formation, in the lesser diameter but greater thickness, in being much more convex dorsally, and in possessing raised and thickened sutures. It differs from *E. limbata* Tappan in the greater thickness, in lacking the reticulate central area, and in having all the chambers more apparent dorsally.

Family GLOBOROTALIIDAE
Genus GLOBOROTALIA Cushman, 1927
GLOBOROTALIA MARGINACULEATA Loeblich and Tappan, n. sp.
Plate 37, figures 19–21; text figure 4A

Test free, trochoid, dorsal side convex, ventral side somewhat flattened, umbilicate, periphery lobate and keeled; chambers numerous, inflated, all visible dorsally, only the six or seven of the last whorl visible on the ventral side; sutures distinct and depressed, nearly straight, slightly thickened dorsally; wall calcareous, finely perforate, ornamented by the spinose keel and numerous fine spines around the outer portion of the test; aperture comparatively large, an arch at the base of the last chamber just ventral to the periphery.

Greatest diameter of holotype 0.403 mm., least diameter 0.295 mm., greatest thickness 0.194 mm. Other specimens range in greatest diameter from 0.202 mm. to 0.425 mm.

Types.—Holotype (Cushman Coll. no. 45665) and paratype of figure 21 (Cushman Coll. no. 45664) and paratypes (Loeblich Coll. no. 1088) from the Paw Paw formation at locality HTL 55, sample 283. Paratype of figure 20 (Cushman Coll. no. 45663) from the Grayson formation at locality HTL 103, sample 419. The hypotype (Cushman Coll. no. 45666) of *Globorotalia delrioensis* Plummer, of text figure 4B, is also from the latter sample, and figured for comparison.

The present species is especially abundant in the Weno, Paw Paw and Main Street formations, a few of the samples being Weno, locality HTL 176, sample 686; Paw Paw, locality HTL 46, sample 255; Main Street, locality HTL 97, sample 401, locality HTL 98, sample 402, and locality HTL 102, sample 418.

Remarks.—This species is somewhat similar to *G. delrioensis* Plummer, with which it occurs. It differs in having straight, rather than curved sutures, a less compressed test, more rounded chambers, less convex dorsal side, and less distinct keel. These differences may be noted in the dorsal, ventral, and edge views of specimens of the two species, which are shown in text figures 4A and B.

The present species is similar in appearance to some species of *Globigerina*, such as *G. planispira* Tappan. It suggests the derivation of *Globorotalia* from that genus by the development of a keel, a more angular periphery, and a more restricted aperture. The keel in the present species suggests its development by a restriction of the larger spines to the peripheral area, with their gradual fusion into a keel. In support of this conclusion, it may be noted that many geologically later species of *Globorotalia* have an early *Globigerina*-like portion, which would seem to be a recapitulation of its ancestry. Because of its geologically older occurrence, *Globorotalia* probably gave rise to the Upper Cretaceous genus *Globotruncana*, rather than the contrary as was stated by Cushman (1940). It is possible, however, that the two genera may have developed independently from *Globigerina*.

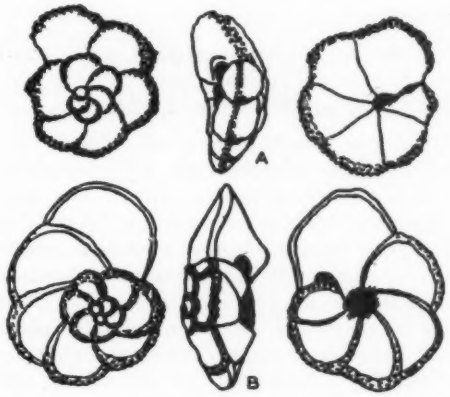

FIG. 4—*A*, *Globorotalia marginaculeata* Loeblich and Tappan, n. sp. Dorsal, edge and ventral views of holotype. All ×53.
B, *Globorotalia delrioensis* Plummer. Dorsal, edge and ventral views of hypotype, for comparison with the above new species. All ×53.

Family ANOMALINIDAE
Subfamily ANOMALININAE
Genus PLANOMALINA Loeblich and Tappan, n. gen.

Genotype, *Planomalina apsidostroba* Loeblich and Tappan, n. sp.

Test free, planispiral, partially evolute, so that earlier coils may be seen on both sides of the biumbilicate test; chambers numerous; sutures may be limbate; wall

calcareous, coarsely perforate; aperture peripheral, an arch at the base of the apertural face of the last-formed chamber, with a distinct lip.

This genus is probably derived from *Anomalina* d'Orbigny by the loss of the early trochoid stage and the development of a completely planispiral test. The aperture has also become peripheral, losing the ventral extension. *Planomalina*, n. gen., resembles *Palmerinella* Bermudez in the presence of the apertural lip, and *Planulina* in the shape of the chambers and evolute character of the test (such as *Planulina ariminensis* d'Orbigny) and the position of the aperture, but *Planomalina* differs from both of these in lacking any trochoid development.

PLANOMALINA APSIDOSTROBA Loeblich and Tappan, n. sp.
Plate 37, figures 22–23b

Test free, small, planispirally coiled, partially evolute, biumbilicate, with periphery of early portion keeled up to the last chamber; chambers numerous, increasing gradually in size, closely appressed, much curved, eight to 10 in the last whorl; sutures strongly curved, bending backward both at the periphery and at the umbilicus, raised and thickened; wall calcareous, coarsely perforate, ornamented by the raised and thickened sutures, which are nodose in the early portion, and the peripheral keel, which has a fimbriate appearance; aperture ovate in outline, at the base of the apertural face of the last-formed chamber, at the periphery of the test, surrounded by a distinct lip, apertural face truncate.

Greatest diameter of holotype 0.482 mm., least diameter 0.317 mm., greatest thickness of last chamber 0.151 mm. Greatest diameter of paratype of figure 22, 0.367 mm., other specimens from 0.245 to 0.533 mm. in diameter.

Types.—Holotype (Cushman Coll. no. 45667), figured paratype (Cushman Coll. no. 45668) and paratypes (Loeblich Coll. no. 1090) all from the Main Street formation at locality HTL 102, sample 418. This species is rare in the Weno formation, abundant in the Paw Paw and Main Street formations, and we also have it in the Georgetown formation.

Remarks.—*Planomalina apsidostroba*, n. sp., somewhat resembles a ventral view of *Planulina ariminensis* d'Orbigny, but differs from that species in being completely planispiral and bilaterally symmetrical, less compressed and in possessing the larger peripheral aperture, surrounded by a lip.

This species also resembles *Planulina cocoaensis* Cushman in the dorsal view of the latter, in size, and in number, shape and arrangement of chambers, but differs in the greater thickness, biumbilicate and bilaterally symmetrical test, rather than being slightly trochoid with a ventral boss, in having a fimbriate keel, truncate apertural face, and large rounded peripheral aperture.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 3, PP. 259–260, 2 TEXT FIGS., MAY 1946

A PLEISTOCENE OVIS CANADENSIS FROM NEW MEXICO

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ABSTRACT—A portion of a skull consisting of the horn cores, occiput, and frontal region of an *Ovis canadensis* from northwestern New Mexico is reported.

NOTWITHSTANDING the present, or Recent, distribution of bighorn sheep from northern Alaska southward into Lower California and eastward into North Dakota, their fossilized remains are rarely found. Therefore, the discovery of the fossil horn cores, occiput, and frontal region of an *Ovis* ram (O.M.P. 21-1-S28) in the San Juan River about 4½ miles upstream from Bloomfield, New Mexico, is of particular interest. The specimen was found by Mr. Roy Sullivan in 1920 and is now owned by his son, Mr. Daniel Sullivan. It was loaned to me by Mrs. Roy Sullivan. Front and side views are shown in figures 1 and 2.

Recent species supposed to have been derived from Pleistocene sediments outside of the region of continental glaciation should be examined very critically in order to authenticate their age. Some specimens, however, are obviously fossil because of their location, the degree of replacement, or the association with other forms. The skull of *Ovis* had apparently been dislodged from a gravel bank, which contained teeth and bones of *Elephas columbi* a little farther upstream. It had been transported only a short distance. The specimen is in excellent condition and required no cleaning or restoration. The conditions under which it was found and the degree of replacement indicate its antiquity.

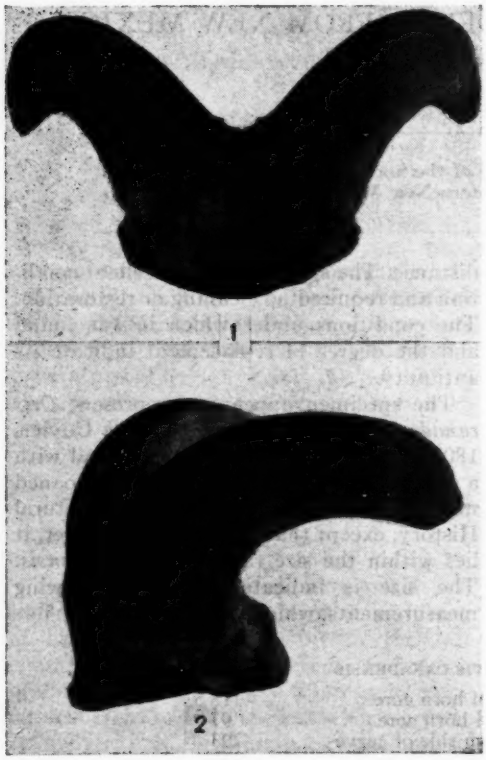
The specimen appears to represent *Ovis canadensis* Shaw, 1804 (*O. montana* Cuvier, 1805). It agrees in almost every detail with a Recent specimen of *O. canadensis* loaned me by the American Museum of Natural History, except that it is larger. However, it lies within the size range of *O. canadensis*. The size is indicated by the following measurements, which are in millimeters:

DIMENSIONS OF OVIS CANADENSIS

1.	Maximum diameter at base of horn core	118.5
2.	Minimum diameter at base of horn core	97
3.	Length of horn core on bottom side of curve	203
4.	Length of horn core on top side of curve	317
5.	Circumference of horn core at base	346
6.	Circumference of horn core 3″ above base	263
7.	Greatest diameter at tips of right core	63.2
8.	Smallest diameter at tip of right core	34
9.	Greatest width at outer margins of tips of cores	413
10.	Minimum distance between horn core bases	28
11.	Distance between outer margins of orbits	173
12.	Maximum diameter of condyles	62.8
13.	Width of occiput above lateral sulci	68
14.	Maximum diameter of occiput	103
15.	Width of basioccipital	40
16.	Length of basioccipital	73

The horn cores are massive and thick in proportion to their length, their maximum length being only 29 mm. greater than their circumference at the base, where the circumference is 346 mm. and compares rather favorably with "the largest horns of *Ovis montana* ever figured and recorded to this date," as reported by Hornaday in the 5th Annual Report of the New York Zoological Society in 1901.

The horn of the Hornaday specimen measured 471 mm. in circumference at the base; but a part of its great circumference



FIGS. *1, 2—Ovis canadensis* Shaw. Front and lateral views of skull crown and horn cores from San Juan River about 4½ miles above Bloomfield, New Mexico. The dimensions are listed in the table of measurements.

is due to the fact that the horn sheath was included in these measurements.

The Bloomfield specimen agrees with *O. canadensis* in the absence of side grooves on the horn cores, a feature which is well developed on *O. dalli*. The latter species is, in general, much smaller than *O. canadensis;* a fact borne out by the present specimen. The horn cores are stubby, penetrating the sheath for a distance somewhat less than one-half the total length of the horn. While the cores are somewhat flattened laterally, especially toward their outer limits, their bases are oval, the greater diameter being roughly antero-posterior.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 3, PP. 261–266, PLS. 38, 39, MAY 1946

FOSSIL EGG CAPSULES OF CHIMAEROID FISHES

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ABSTRACT—To the three previously reported fossil egg capsules of chimaeroid fishes this paper adds five specimens and assigns all to *Chimaerotheca*, a new form genus. *Chimaerotheca germanica* and *C. besselsi* are from the Jurassic of Germany; *C. wyomingana*, from the Upper Cretaceous of Wyoming; *C. newmexicana*, from the Upper Cretaceous of New Mexico; *C. montanana*, from the Upper Cretaceous of Montana; and *C. alaskana*, from the Oligocene of Alaska.

LATE in 1944 I found among the specimens of fossil plants in a collection brought from Alaska by Don J. Miller, of the U. S. Geological Survey, a curious impression (pl. 38, fig. 4) on fine-grained sandstone that recalled four other baffling fossils, which I had set aside 10 years ago to await further light on their identity. On comparing the two sets of specimens I was convinced of their organic similarity and relationship and began casting about in earnest for clues leading to their correct identification. Having found all these specimens among collections of fossil plants I surmised that the collectors had assumed that they represented plants or parts of plants, probably portions of palm or cycad leaves, an idea which, as the illustrations show, is not altogether fanciful. The resemblance, however, seemed to me superficial, and, remembering the circumstance that all the fossils came from brackish-water or marine sandstone strata, I turned to the consideration of possibilities among remains of marine animals. Thus, thinking of fishes, I was reminded of a paper by Gill (1905) reporting a Cretaceous chimaeroid egg case. C. W. Gilmore, of the U. S. National Museum, after seeing my material, produced Gill's specimen (pl. 38, fig. 8) and confirmed my tentative identification. To him I am particularly indebted for further valuable help and friendly encouragement in the preparation of this paper.

The living chimaeroid fishes, although somewhat sharklike in appearance and in having cartilaginous skeletons, are neither sharks nor ancestral sharks, but a divergent group that comprises about 25 species distributed among the genera *Chimaera*, *Callorhynchus*, *Harriotta*, and *Rhinochimaera*. These fishes are found in all parts of the world. Some species may be taken in shallow coastal waters, and others at abyssal depths. They range from 60 to 200 cm. in length, display delicate and varied coloration, have powerful dental plates, are omnivorous, probably live in schools, and reproduce by laying large, tough, more or less leathery, brown egg capsules, which are attached by caudal filaments to rocks or other objects. Full details, including colored illustrations, concerning the appearance and anatomy of these fishes can be found in Garman (1899; 1904; 1911) and Dean (1906; 1909; 1912). The latter investigated *Chimaera colliei* Bennett from the Pacific Coast of the United States, made extensive studies of its life habits and embryology, and arrived at significant conclusions pertaining to the evolution of the group. Dean's descriptions and illustrations of the egg capsules of the genera of chimaeroids are particularly enlightening in the present connection.

The egg capsules of living species (see pl. 39) are dartlike to elliptic in overall outline and consist of two obvious parts—the bilaterally symmetric, tough, leathery, centrally located embryo case and a thin membrane or web of variable width that extends outward from the case in the horizontal plane dividing the case into dorsal and ventral sides. These sides, except the dorsal in *Chimaera*, which is keeled, are ordinarily so similar in appearance that, casually examined, they cannot be readily distinguished. For purposes of description the case may be said to have snout, trunk, and tail portions, although these regions are in reality poorly defined. It may be smooth or

finely striated and tapers in varying fashion toward both ends, the posterior being usually the more attenuated. The anterior or snout portion is valved like the bilabiate corolla of some figworts and, at the critical moment, opens horizontally, permitting the young fish to escape. Minuter details, such as lateral ventilating pores or slits, both fore and aft, may be present on the case, but these seem never to have been preserved in the fossil impressions, the sandstone probably being too coarse a medium for recording such delicate features. The membrane or lateral web is thin but may be strengthened by simple or branched riblike thickenings called rugae or costae. These, for the most part, are curved or arched, the convex sides facing forward. The margin of the web may be entire or fimbrillose. Although numerous egg capsules have been collected, none, so far as I am aware, has ever been observed in place. Consequently, the function of the web, whether for helping to maintain a horizontal position of the capsule or for some other purpose, remains conjectural. Other details may be significant in a complete diagnosis, but for convenience the several genera may be distinguished by the outlines of their embryo cases, as follows: *Chimaera*, tadpole-shaped; *Callorhynchus*, spindle-shaped with elliptic trunk; *Rhinochimaera*, spindle-shaped with oblong trunk, the snout being notably wider than the tail portion; *Harriotta*, spoon-shaped, the tail portion being conspicuously widened at the "handle" of the spoon.

Of interest here is the conclusion Dean (1909, p. 265) drew from his tables of measurements of egg capsules and mature fishes, namely, that the "form and size of even an adult chimaeroid can be predicted from its egg-capsule with considerable accuracy". The adult is approximately four times the length of the egg capsule.

Remains attributed to chimaeroid fishes are known from the Middle Devonian to the present. However, there seems to be some doubt concerning the precise identity of the pre-Jurassic specimens. According to Dean's (1906, p. 134) table the Cretaceous was probably the heyday of these fishes. Most species (Hussakof, 1912) have been founded on mandibular plates, teeth, or dorsal fin spines, but a few on entire or nearly entire fishes. Fossil egg capsules appear to be rare, only three, or to be more precise, two and one-half, having been reported to this date. Two of these represent species from the Middle Jurassic of Germany, and the third is the specimen reported by Gill from the Upper Cretaceous of Wyoming. The present collections add five specimens to the list—three from the Upper Cretaceous of New Mexico, one from the Upper Cretaceous of Montana, and one from the Oligocene of Alaska. Obviously, this small number of specimens representing isolated portions of geologic time and scattered geographic localities, reveals only a few items of chimaeroid ancestry; but this condition of scarcity may be remedied once paleontologists are aware of the possibilities.

The fossil "species" of chimaeroid capsules so far reported were tentatively but hesitantly assigned to genera and species based on dental plates or teeth. That the capsules may have been produced by the species that bore the teeth is possible but hardly demonstrable. The Jurassic capsules were taken from a locality different from that yielding the teeth to which they were referred. Furthermore, most of the 33 Jurassic species of chimaeroids are based principally on teeth, thus greatly increasing the improbability of assigning the capsules to the correct tooth genus. No teeth were found with any of the American specimens. In view of this uncertainty concerning the relationship of egg capsules and teeth among fossil chimaeroids I have concluded to erect a form genus to receive all kinds of fossil chimaeroid egg capsules, leaving any speculations as to probable affinities for treatment in the discussion of each species. I, therefore, propose the name *Chimaerotheca* for such egg capsules. It is derived from *chimaero*, pertaining to chimaeroid fishes, and *theca*, capsule, case, container.

The specimens assigned to *Chimaerotheca germanica* and *C. besselsi* were said to have been deposited in the Natural History Museum at Stuttgart, Germany. All the remaining specimens are in the United States National Museum, Washington, D. C.

CHIMAEROTHECA Brown, n. gen.

Egg capsules in general comparable to

those of living chimaeroid fishes, composed of an embryo case fringed by a more or less rugose lateral membrane or web in the plane that divides the case into dorsal and ventral sides.

Genotype: *Chimaerotheca wyomingana* Brown, n. sp.

CHIMAEROTHECA WYOMINGANA Brown, n. sp.
Plate 38, figure 8

Chimaeroid egg-case. Gill, 1905, pp. 601–602. Darton, Blackwelder, and Siebenthal, 1910, p. 10.—Hussakof, 1912, p. 224.
Elasmodus? Dean, 1909, p. 267, pl. 37.

One specimen represents this species. It is a nearly entire, elliptic or slightly ovate capsule, 19 cm. (but originally probably 20 to 25 cm.) long and 9 cm. wide. The embryo case is spindle-shaped to slightly oblong, the greatest width of the trunk portion being 3 cm. at a point well behind the middle of that area. The snout is somewhat wider than the tail portion, but its termination is not preserved. The tail portion first contracts rather abruptly behind the trunk and then tapers narrowly and evenly to a blunt point. The web averages 2.5 cm. in width and maintains this width around the case. Its rugae are simple, unbranched costae, numerous and arched, with the convex sides facing forward.

The features of this capsule approximate roughly those of the capsules of *Rhinochimaera* (pl. 39. figs. 4, 8). The parent fish was probably 80 cm. long.

This specimen was collected by N. H. Darton and referred to Theodore Gill for identification. Gill (1905) recognized it as a chimaeroid egg capsule and noted its resemblance to the capsules of *Rhinochimaera* and *Harriotta* but did not describe or name it, leaving that function, as he said, to Bashford Dean, who was at that time preparing a paper on chimaeroid fishes. Dean's first paper (1906), the materials and proof of which Gill had seen, cited Gill's article in the extensive bibliography but did not mention Gill's specimen in the text. In 1909, however, Dean figured the specimen and discussed it at length but did not formally name it beyond suggesting that it might have been produced by a female belonging to a species of the Cretaceous tooth genus *Elasmodus*. The Mesaverde formation, which yielded this capsule, although composed of fresh-water continental materials over wide areas, at some localities, as in this instance, has brackish-water or marine facies and contains marine fossils, such as *Inoceramus*, *Avicula*, etc.

Occurrence.—Upper Cretaceous. In the basal sandstone of the Mesaverde formation, 1 mile east of Table Mountain, 20 miles west of Laramie, Wyoming. (Type, U.S.N.M. 5994.)

CHIMAEROTHECA NEWMEXICANA Brown, n. sp.
Plate 38, figures 3, 5, 6

Three specimens represent this species. The best specimen indicates that the original length of the capsule was about 25 cm. and the width 10.5 cm. The outline of the embryo case is more nearly that of a spindle than a tadpole, but the greatest width of the trunk is somewhat behind its midsection, making the trunk oblong. Both anterior and posterior portions taper fairly gradually, the anterior broadly to a blunt, rounded to squarish edge, and the posterior narrowly through an attenuated caudal area to a slender point. The web is nearly 4 cm. wide and of approximately even width around the case. The arched rugae are numerous and coarse at their origin beside the case, some remaining simple, but others branching once or twice before reaching the margin, the convex sides facing forward.

These capsules resemble in general the specimen called *Chimaerotheca wyomingana*, except that the rugae of the latter are simple. They combine features displayed by the capsules of *Callorhynchus* (pl. 39, figs. 1, 2) and *Rhinochimaera* (pl. 39, figs. 4, 8). The parent fishes were probably 1 meter long.

Orestes St. John collected these specimens in the middle 1870's. For an undetermined number of years they lay in the collections of the United States National Museum as unidentified plants or problematica. Portions of the Trinidad sandstone, in which the fossils were found, contain marine shells, *Halymenites*, and fish bones and scales.

Occurrence.—Upper Cretaceous. Trinidad sandstone. Figure 6 (type, U.S.N.M. 16889), from near Raton, New Mexico. Figure 3

(U.S.N.M. 16888) and figure 5 (U.S.N.M. 16886), from Crow Creek Canyon, 1 mile northwest of Koehler, New Mexico

CHIMAEROTHECA MONTANANA
Brown, n. sp.
Plate 38, figure 7

This poorly preserved fragment perhaps scarcely deserves a specific name, and I give it one very reluctantly. It represents only a portion of what appears to be a spindle-shaped embryo case, with greatest width of 2 cm., and the stumps of the medium thick rugae of the web, which is here not clearly demarked from the embryo case—a circumstance that leaves some doubt concerning the identification. Between the bases of the rugae the sinuses are well rounded.

The shape of the case and the distribution of the rugae of this specimen suggest resemblance to the capsules of *Callorhynchus*. The parent fish was probably 50 cm. long.

This fossil was collected by Barnum Brown, according to the label left with it in the fossil plant collections of the United States National Museum. The area from which it came, however, was also examined by Eugene Stebinger about 1912, who named the Horsethief sandstone of the Montana group, the type locality being Horsethief Ridge in the Blackfoot quadrangle, Montana; and Stebinger may have had some connection with bringing this specimen to Washington. The Horsethief sandstone contains brackish-water and marine fossils.

Occurrence.—Upper Cretaceous. From Horsethief sandstone of the Montana group in sec. 5, T. 31 N., R. 9 W., 3 miles above Holy Family Mission on Two Medicine River, Montana. (Type, U.S.N.M. 17020).

CHIMAEROTHECA ALASKANA Brown, n. sp.
Plate 38, figure 4

One specimen represents this species. It is nearly entire and narrowly elliptic in overall appearance, possibly 15 cm. long and 7 cm. wide originally. The outline of the embryo case is that of a narrow spoon, there being a small expansion at the posterior end of the long caudal "handle" portion. Anterior to the trunk is a constriction followed by a rounded-blunt, spatulate expansion forming the snout. The web, approximating 2.5 cm. in width, makes an even-bordered fringe around the capsule, except at the anterior end. The rugae are numerous, of medium thickness, once or twice branched, and curved with the convex sides facing forward.

This capsule resembles those of *Harriotta* (pl. 39, fig. 7) very closely, except that the rugae are branched, not simple, as in the latter. The parent fish was probably 60 cm. long.

The specimen was collected by Don J. Miller in 1944. The Split Creek sandstone member of the Katalla formation yields marine mollusks and fish vertebrae indicative of Oligocene age.

Occurrence.—Oligocene. From Split Creek sandstone member of the Katalla formation at head of Split Creek, 2.16 miles N. 60° W. from the intersection of the two principal tributaries of Burls Creek and 7.27 miles N. 27° E. of Katalla on Controller Bay, Alaska. (Type, U.S.N.M. 16887).

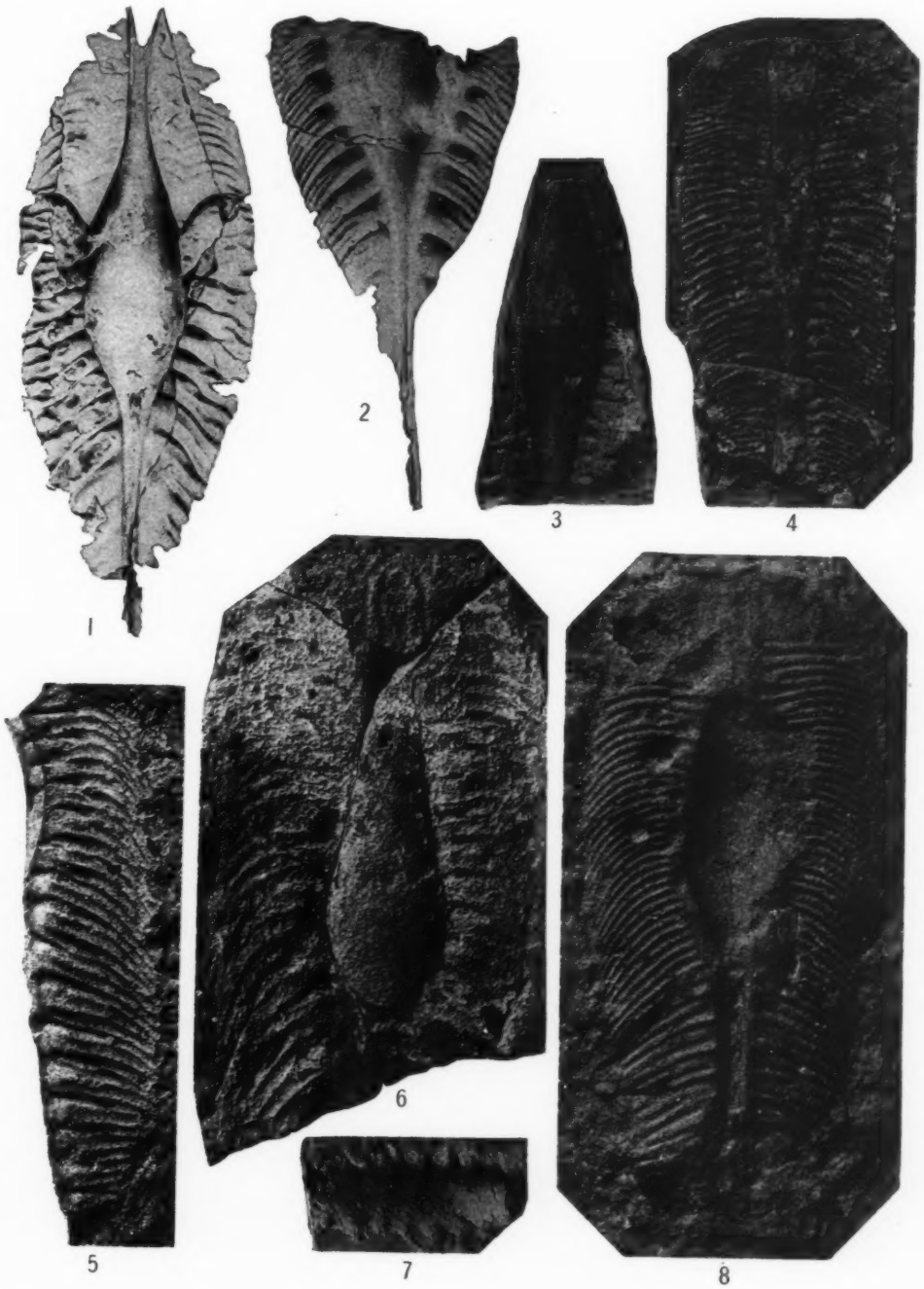
CHIMAEROTHECA GERMANICA Brown, n. sp.
Plate 38, figure 1

Chimaeroid egg capsule. Bessels, 1869, pp. 152–155, pl. 3, fig. 1.

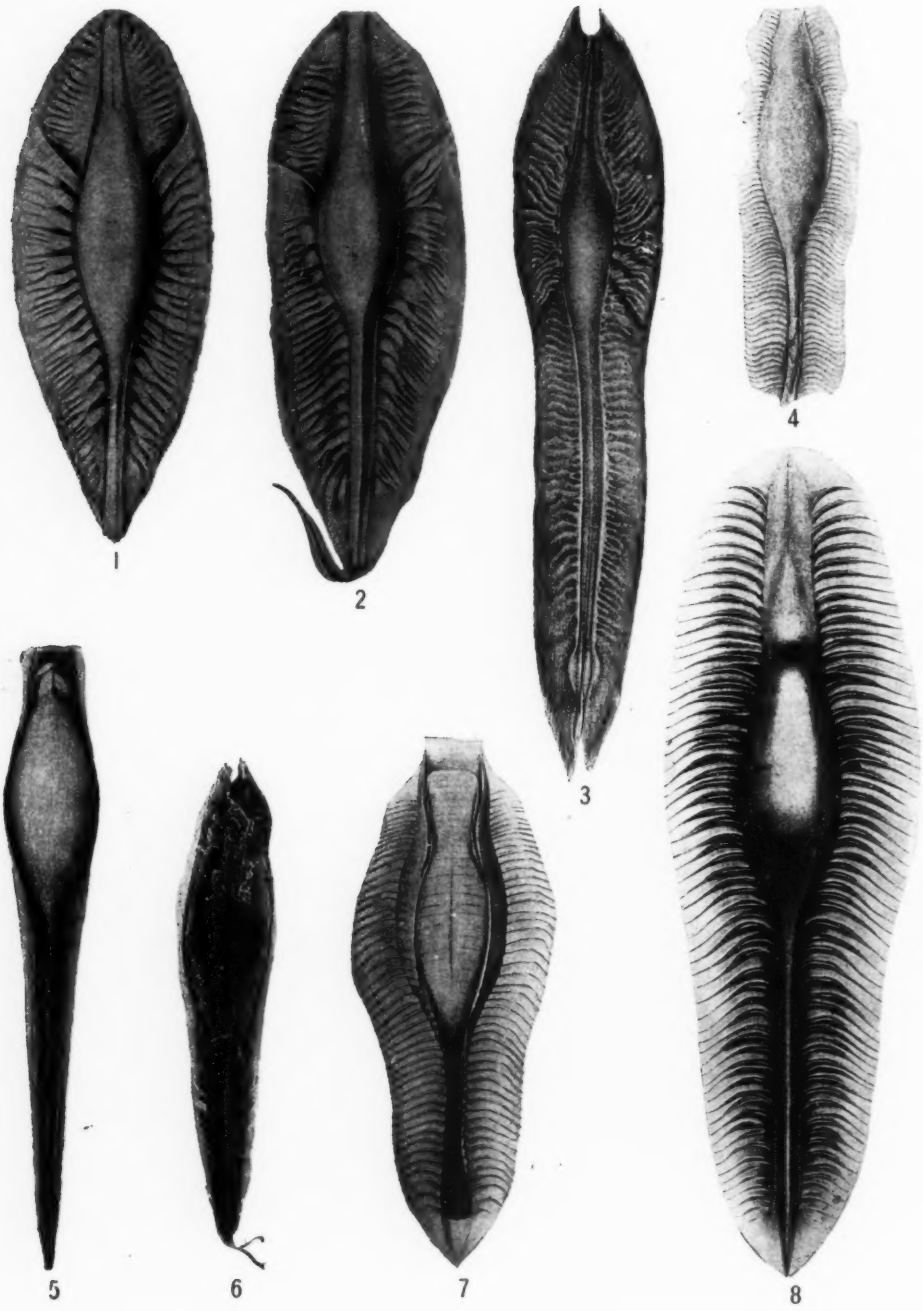
Aletodus ferrugineus Jaekel (part), 1901, pp. 551–556, pl. 22, fig. 3.—Dean, 1906, p. 31, fig. 14.

EXPLANATION OF PLATE 38

FIGS. *1–8*—Fossil chimaeroid egg capsules, ×½. *1*, *Chimaerotheca germanica* Brown, n. sp., from the Dogger (Middle Jurassic), near Heiningen in Württemberg, Germany. (After Jaekel.) *2*, *C. besselsi* Brown, n. sp., from the Dogger (Middle Jurassic) near Heiningen in Württemberg, Germany. (After Jaekel.) *3*, *5*, *6*, *C. newmexicana* Brown, n. sp., from the Trinidad sandstone (Upper Cretaceous) near Raton (fig. *6*) and Koehler (figs. *3*, *5*), New Mexico. *4*, *C. alaskana* Brown, n. sp., from the Split Creek sandstone member of the Katalla formation (Oligocene), northeast of Katalla, Alaska. *7*, *C. montanana* Brown, n. sp., from the Horsethief sandstone member of the Montana group (Upper Cretaceous) on Two Medicine River, Montana. *8*, *C. wyomingana* Brown, n. sp., from the Mesaverde formation (Upper Cretaceous) west of Laramie, Wyoming.



Brown, Egg Capsules of Chimaeroid Fishes



Brown, Egg Capsules of Chimaeroid Fishes

This specimen is a nearly entire capsule, narrowly elliptic in outline, 17.5 cm. long and 7 cm. wide. The case is spindle-shaped and 3 cm. in diameter at its widest point. The web approximates 2 cm. in width and maintains this width evenly around the case. Its rugae are few, coarse, and obscurely branched. They curve slightly in the posterior but more prominently in the anterior portion, where the convex sides face forward. A little beyond the middle of the trunk of the case, anteriorly, there is a pair of unusually heavy rugae with convex sides facing forward. These appear to have counterparts in living *Callorhynchus* capsules (pl. 39, figs. 1, 2). Beyond the pair of heavy rugae are more numerous rugae, less coarse, apparently unbranched, but broken by conspicuous angles, a feature displayed by no living species. As I have not seen this specimen I cannot vouch for the accuracy of the illustration, which, however, seems somewhat more realistic than that of Bessels. Indeed, some features of the specimen, as for example, the rather abrupt change in the character of the rugae at the prominent anterior ridge or fold suggest that the forward portion represents an impression of part of one side, and the rear portion a part of the reverse side of the original egg.

The general similarity of this capsule to those of *Callorhynchus* was remarked by Bessels, Jaekel, and Dean, but Dean emphasized the differences between them and demurred from assigning the capsule to *Callorhynchus*. The parent fish was probably 70 cm. long.

This and the specimen I am referring to *Chimaerotheca besselsi* were first reported and correctly classified by Bessels, then discussed and refigured by Jaekel, who assigned them to a new tooth genus erected for teeth from a different horizon at another locality in the Dogger of Württemberg, Germany. I have stated in the introduction why I consider it infeasible to refer these capsules to a tooth genus.

Occurrence.—Middle Jurassic. From a marine sandstone in the lower Dogger near Heiningen, in Württemberg, Germany. Specimen said to be in the Natural History Museum, Stuttgart, Germany.

CHIMAEROTHECA BESSELSI Brown, n. sp.
Plate 38, figure 2

Chimaeroid egg capsule. Bessels, 1869, pp. 152–155, pl. 3, fig. 2.
Aletodus ferrugineus Jaekel (part), 1901, pp. 551–556, pl. 23, fig. 4.

This specimen represents the posterior half of an elliptic capsule, whose length must have been at least 25 cm. and width 7 cm. The case was evidently spindle-shaped and 3.5 cm. in greatest diameter. The web, averaging less than 2 cm. in width, encircles the case evenly. The main rugae are few, and seldom, if at all, branched. They separate groups of two or sometimes three, minor, and apparently unbranched rugae. All the rugae are only slightly arched.

It is possible that this specimen may be a variant of *Chimaerotheca germanica*, but the differences in size and in the features of the rugae of the two specimens impel me to regard the specimens as representing different species. I name this species for Emil Bessels, who was the first person to recognize the true status of this and the specimen of *C. germanica*, which had been known for 40 years to the members of the Verein für vaterländische Naturkunde in Württemberg but had remained unidentified, there being but one suggestion, namely, that they might represent crustaceans.

Occurrence.—Middle Jurassic. From a marine sandstone in the lower Dogger near Heiningen, in Württemberg, Germany. Specimen said to be in the Natural History Museum, Stuttgart, Germany.

EXPLANATION OF PLATE 39

FIGS. *1–8*—Egg capsules of living chimaeroids, showing ventral aspect. (After Dean, 1906. Courtesy of the Carnegie Institution of Washington.) *1, Callorhynchus* sp., from Cape of Good Hope, Africa, ×½. *2, Callorhynchus* sp., from Australia, ×½. *3*, Unidentified capsule from mid-Pacific, ×½. *4, Rhinochimaera indica* from Indian Ocean, ×⅔. *5, Chimaera monstrosa*, from Norway, ×½. *6, Chimaera colliei*, from Puget Sound, Washington, ×½. *7, Harriotta?* sp., from North Atlantic, ×½. *8, Rhinochimaera pacifica* from Misaki, Japan, ×½.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 3, PP. 267–268, MAY 1946

A NEW SPECIES OF DOLATOCRINUS FROM THE TRAVERSE (MIDDLE DEVONIAN) OF MICHIGAN

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ABSTRACT—In his review of the species of *Dolatocrinus*, Springer (1921) described a new species, *D. incisus*. Through inadvertence two distinct species were used on the plate to illustrate the form. The description in the main and the stratigraphic ascription apply to only one of these. The species are here separated and proper stratigraphic horizons assigned to them.

DOLATOCRINUS INCISUS Springer

Dolatocrinus incisus SPRINGER, 1921, U. S. Nat. Mus. Bull. 115, p. 49, pl. 12, figs. 12(?), 13 (not figs. 8–11).

SPRINGER (1921, p. 49) gives as horizon and locality "Hamilton (Traverse) shales; Alpena, Michigan," which is practically without meaning. In the text, however, he states that the species is associated with *Dolatocrinus asterias*. *D. asterias* is found in the upper Alpena limestone, possibly ranging upward into the Dock Street clay of Grabau (1902, pp. 178, 192). In other collections from the upper Alpena specimens referable to *D. incisus* have been found, and the lithology of the lectotype is unmistakably that of the upper Alpena.

There is one point that may be taken up here. Springer (1921, p. 49) gives as the locality and horizon of *D. asterias*, "Hamilton group: Alpena and Partridge Point, Michigan." I can find no specimen in the Springer collection from Partridge Point labeled *D. asterias*, and in all the extensive collections from that locality I have not seen a specimen closely resembling the species. It would appear that Springer's citation of Partridge Point as a locality was based on Wood (1904, p. 73). Among the material used by Wood the abnormal specimen, figure 7, page 72, is the only one labeled as from Partridge Point. This specimen is a mutilated fragment of a dorsal cup of uncertain specific placement. The preservation of the specimen and the matrix adhering to it definitely preclude its assignment to the beds at Partridge Point. It could well be from the Alpena limestone.

In the text Springer states that two specimens of *D. incisus* are figured. In the plate legend three specimens are so designated. As a matter of fact, four specimens are illustrated. Of these, one specimen, plate 12, figure 13, is here chosen as lectotype of *D. incisus* Springer. Figure 12 of the same plate is stated by Springer to be the tegminal view of specimen figure 11. Such is not the case. It is another specimen altogether and may be a distinct species. The explanation probably is that specimens shown in figures 12 and 13 are the two mentioned in the text and the figures of the other two specimens were erroneously included in the species.

Specimens of *D. incisus* are found associated with *D. asterias* in the collections made by Rominger and myself from the upper Alpena limestone in the now obliterated Collins and Fox Quarries. It has also been found in the same association at the same horizon by G. Arthur Cooper and others in the large quarries north of Alpena. The type specimen itself was collected by me.

Horizon and locality.—As indicated above, *D. incisus* is known only from the upper part of the Alpena limestone and possibly from the Dock Street clay of Grabau (1902, pp. 178, 192). The locality of the holotype was the old Collins Quarry about 1 mile north of Alpena, Michigan.

DOLATOCRINUS GRABAUI Kirk, n. sp.

Dolatocrinus incisus SPRINGER (part), 1921, U. S. Nat. Mus. Bull. 115, p. 49, pl. 12, figs. 8–1.1

As holotype of this species I have chosen the specimen illustrated by Springer as figures 8–10. The original of figure 11, a relatively young specimen, stands as paratype.

This is a moderately large species, the

theca of the holotype having a diameter of 36 mm. and a height of 22 mm. The dorsal cup has a height, to the level of the arm openings, of 15 mm. These measurements are obviously those of an unusually low, broad form, with a low tegmen. The walls of the cup are nearly vertical. The base of the cup is deeply excavated. The depressed area involves the basals, radials, and the greater part of the first primibrachs. The central pit is very deep, having a depth of 8 mm., bringing the basals approximately to the level of the distal faces of the first secundibrachs. The tegmen is low, arched, and with well-defined, depressed interambulacral areas.

The relative size and the shape of the plates of the theca can be seen in Springer's illustrations. The relatively large size of the first primibrach and of the first secundibrach are interesting.

The ornamentation of the plates is fairly well shown by Springer's figures, though the draftsman in retouching the photographs emphasized the stellate pattern, which is less conspicuous in the specimen. The carinae are all of approximately equal prominence in the basal view. In the centers of some of the more distal plates the carinae are more accentuated. The carinae are sharply defined, with knifelike edges. The plates of the tegmen are strongly ornamented with sharp vermicular ridges.

This handsome species is named in honor of Dr. A. W. Grabau, through whose kind office I made my first acquaintance with the Michigan Devonian.

Horizon and locality.—The types were collected by me at the now obliterated Warner's Brickyard, within the city limits of Alpena, Michigan. They came from the 1-foot capping limestone bed described by Grabau (1902, p. 194). Warthin and Cooper (1943, p. 591) place these beds within their Potter Farm formation.

Remarks.—*Dolatocrinus grabaui* is a larger form than *D. incisus* and is relatively broader and lower both as regards the dorsal cup and the theca as a whole. The base of *D. incisus* is flattened, with a relatively small and sharply defined central pit. In *D. grabaui* the entire base is concave, and the central pit is relatively wider and deeper. The ornamentation of the two species is very unlike except for the basic *Dolatocrinus* pattern. In *D. incisus* the ornamentation consists of low rounded ridges and is comparatively simple. There is a single median ridge traversing the plates of the radial series. Elsewhere in the dorsal cup, as a rule, there is but a single ridge normal to each face of a plate. In a few cups there are two such ridges. In *D. grabaui* the carinae are cleanly cut, with knifelike edges. In an adult specimen, the holotype, three to five parallel carinae traverse the plates of the radial series up to and including the *IIAX*. In the case of the other plates of the cup there are two or more carinae normal to each face of a plate. This gives a pattern of ornamentation comparable in intricacy to any known species of the genus. In the young paratype the carinae are relatively coarser and the pattern simpler.

Type.—The holotype and paratype are in the collections of the United States National Museum, holotype 111754, paratype 111755.

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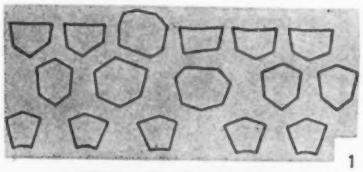
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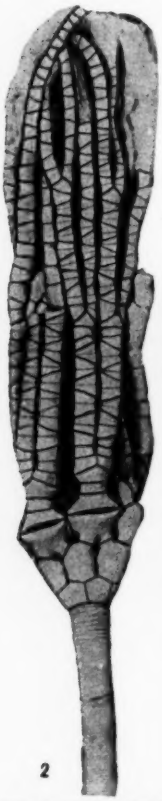
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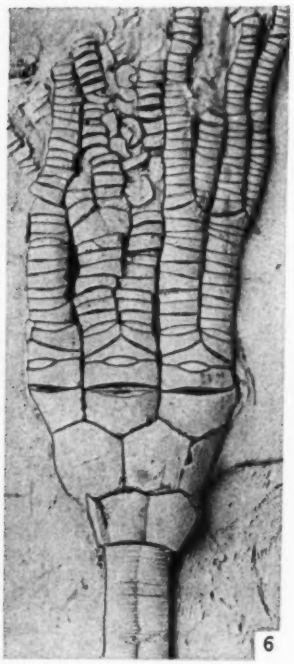
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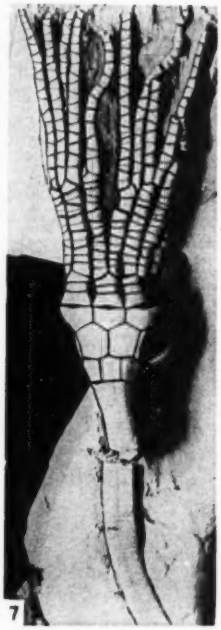
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Kirk, *Corythocrinus*

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 3, PP. 269–274, PL. 40, MAY 1946

CORYTHOCRINUS, A NEW INADUNATE CRINOID GENUS FROM THE LOWER MISSISSIPPIAN

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A NEW crinoid genus, *Corythocrinus*, is proposed for the reception of four new lower Mississippian species. The genus is particularly interesting because it has structural features rarely seen in Paleozoic crinoids.

Genus CORYTHOCRINUS Kirk, n. gen.

Genotype, *Corythocrinus insculptus* Kirk, n. sp.

Generic diagnosis.—Crown: The crown, with its long arms and their compact and erect habit, has a subcylindrical aspect.

Dorsal cup: Obconical to turbinate, with unusually thin plates.

IBB: Large, forming a fair portion of the cup wall.

BB: Large.

RR: Large. Facet full width of plate. Suture gaping. An articular ridge extends nearly the full width of the plate, and dorsad there is a well-defined median ligament pit.

IBr: Three in number in all known species. IBr_1 extends the full width of the *R*, narrowing distad. IBr_2 narrow, at times completely enclosed by the overlapping IBr_1 and *IAx*. *IAx* widens distad.

Arms: Long, relatively slender, dividing by dichotomy. *IIBrr* and *IIIBrr* variable in number as among the rami of one radius and the rami of different radii. In no species has a ramus been observed to divide above *IIIAx*. The arms are remarkable in the great development of syzygial pairs among the ossicles, an unusual structure among Paleozoic Inadunata. The pinnules, given off by each epizygal or alternately by normal *Br*, are long and stout.

Post IR: The single anal plate is large, extending above the level of the *RR*. In all known species it makes contact with *r post B*. In an allied undescribed genus, the anal plate may or may not make contact with the *r post B* within a single species.

Ventral sac: The ventral sac is long and slender. The anal plate supports two tube plates, which in turn support linear series of heavy tube plates. The ventral surface of the sac is covered by a flexible incompetent integument composed of small plates.

Column: The column is large. In section it is round or obscurely pentagonal, with rounded angles. The columnals are unusually low.

Geologic and geographic distribution.—The earliest known species is from the upper part of the Burlington limestone ("Upper Burlington") of Burlington, Iowa. The latest known species are found in the upper part of the Borden group of Indiana.

Relationships.—*Corythocrinus* represents a novel and unexpected crinoid structure. It apparently stands without close relationship to any described genus, although there are undescribed forms which have characters in common with it. Of described genera *Lebetocrinus* resembles *Corythocrinus* in having a single anal plate, resting on the *post* and *r post BB*. The columns are somewhat similar in the two genera and in both the plates of the cup are thin. The type of articulation of the *IBr* on the *R* is quite unlike in the two genera. In *Lebetocrinus*

EXPLANATION OF PLATE 40

FIGS. *1*—*Corythocrinus*. Plate diagram of dorsal cup.
2, 3—*Corythocrinus insculptus* Kirk, n. sp. *2*, Left posterior view of holotype, ×1; *3*, portion of arms of holotype, ×2. (p. 272)
4—*Corythocrinus gracilis* Kirk, n. sp. Anterior view of holotype, ×1. (p. 271)
5–7—*Corythocrinus fragilis* Kirk, n. sp. *5*, Posterior view of paratype, ×1; *6*, anterior view of holotype, ×1; *7*, anterior view of young individual, paratype, ×1. (p. 270)
8—*Corythocrinus tenuis* Kirk, n. sp. Anterior view of holotype, ×1½. (p. 273)

there is but one primibrach as against the three of *Corythocrinus*. *Corythocrinus* is of the straight-facet type, with a gaping suture that extends the full width of the radial. *Lebetocrinus* has a crescentic facet at times not extending the full width of the radial and with a closed suture between the radial and the first primibrach. The arms of *Corythocrinus* are relatively slender as compared with *Lebetocrinus*, and with their erect, compact habit give quite a different aspect to the crown. The great development of syzygial pairs of ossicles in the arms of *Corythocrinus* is quite unlike the arm-structure of *Lebetocrinus*. In *Corythocrinus* the anal plate supports two plates as against one in *Lebetocrinus*.

SPECIES REFERRED TO THE GENUS

CORYTHOCRINUS FRAGILIS Kirk, n. sp.
Plate 40, figures 5–7

This species is represented by two adult individuals, one showing the posterior side and the other the anterior. Another smaller crinoid (fig. 7) might equally well be considered as representing another species or being a young individual of *Corythocrinus fragilis*. The variation in structure between young and adult inadunate crinoids is often very great. The exact determination of specific identity of juvenile forms is nearly impossible without extensive collections and reasonably complete ontogenetic series. However, immature crinoids can as a rule be recognized by structural and at times lithologic characters and a reasonably accurate opinion formed as to their specific assignment, provided the adults are known. It has been thought best to consider the original of figure 7 as a young specimen of *Corythocrinus fragilis*.

Judging by the relative length of arms and height of dorsal cup in the young individual, and the rate of taper of the rami of the large specimens, it seems probable that the arms had a length of at least five times the height of the dorsal cup. If such were the case the adult crowns must have had a height of not less than 10 cm. The dorsal cup is obconical, in an uncrushed condition having a height about equal to the diameter at the arm bases. The plates of the cup are unusually thin for a crinoid of this size, the infrabasals and basals apparently averaging about 0.7 mm. in thickness in an adult individual. The surface of the plates of the dorsal cup are thickly set with papillae that tend to coalesce. The thinness of the plates results in an incompetent structure that is readily crushed, with the component plates dissociated and thrown out of alignment.

The infrabasals are pentagonal in outline, higher than wide, with a height approximately one-third the height of the dorsal cup. The basals are hexagonal in outline with the exception of the right posterior, which is heptagonal. The basals are higher than wide and have a height nearly one-half the height of the cup. The right posterior basal supports the anal plate on its left upper shoulder. The radials are low and broad, with a straight radial facet extending the full width of the upper face. There is a transverse articulating ridge extending nearly the full width of the radial and dorsad to this a large median ligament pit. The anal plate is very large. Below, it rests on the posterior and right posterior basals. Laterally, it abuts against the right and left posterior radials and extends well above them. The anal plate, in the one well-preserved adult (fig. 5) that shows the posterior interradius, supports two tube plates.

The ventral sac is broken off at a height of about 22 mm., and its lower portion is partially covered by the rami of the left posterior radius. The right tube plate, which holds a submedian position on the anal plate, supports a second tube plate of nearly the same size above, and a much smaller one on its right upper shoulder. The second large tube plate in turn supports a third large tube plate in the median line and a smaller one on its right upper shoulder. The left tube plate resting on the anal plate is smaller than the one to the right and supports a second tube plate above. The tube plates resting on the right shoulder of the right tube plate and on its superior face support linear series of tube plates above.

The arms are fairly stout and as noted above probably have a length at least five times the height of the dorsal cup. The

brachials, with the exception of the syzygial pairs, were so loosely united that the rami disintegrated quickly into their component elements. The first primibrach extends the full width of the radial and articulated with the radial along a transverse ridge that extends nearly the full width of the radial. As is usual in this type of articulation, there is a widely gaping suture between the first primibrach and the radial. The second primibrach is lenticular in form and in the adult specimens is entirely enclosed by the first primibrach and the primaxil. This unusual structure is well shown in the figures. It will be discussed more at length elsewhere. The primaxil is low and broad. The rami are stout and closely appressed. There are 11 to 13 secundibrachs, of which apparently six to eight are united in syzygial pairs. The syzygies cannot be demonstrated unequivocally, but the close union of the paired brachials and their outline as combined makes such an explanation highly probable. The full number of tertibrachs can be seen in but two specimens. In both there are apparently 24 brachials. Here again among the tertibrachs there are a number of syzygial pairs. The more distal portions of the arms are unknown. The pinnules are long and stout.

The column is large, measuring 9.5 mm. in diameter in one of the adult individuals. The columnals are low, numbering 20 in a distance of 1 cm. in the proximal portion of the column. The nodals and internodals are but slightly differentiated in size. The stem lumen is very large and, as judged by the distal portion of the column of the young specimen as preserved, circular in section. Owing to the thinness of the columnal wall the stem as seen is always flattened. In the collapse of the column breaks occur along definite longitudinal lines. In section the column can be seen to be divided into imperfectly anchylosed pentameres, and it is along the lines of union of the pentameres that the fracturing takes place.

Ontogeny.—In the immature individual there is little worthy of special comment other than the arm-structures. The second primibrach is considerably narrower than the first primibrach and somewhat narrower than the primaxil. It extends the full width of the ramus, however. The general appearance of the three primibrachs is that normal for similar inadunates. It would appear that in the subsequent growth of the individual the growth of the second primibrach is retarded relative to the brachials above and below, permitting the latter to overlap gradually and enclose the second primibrach. The more distal portions of the arms show typical juvenile characteristics with proportionally long brachials and relatively large pinnules. In both the secundibrachs and tertibrachs syzygial pairs are clearly indicated, and in several cases the pinnule arrangement confirms this structure.

Horizon and locality.—One of the adult individuals, the holotype, and the immature specimen come from the upper part of the Borden group at Crawfordsville, Indiana. The other specimen is from the upper part of the Borden group at Indian Creek, Montgomery County, Indiana.

Types.—The holotype and paratypes are in the Springer collection in the United States National Museum; holotype, S. 4486; paratypes, S. 4487, S. 4488.

Remarks.—The large size of this species, the stoutness of the arms, and the peculiar character of the second primibrach in adult individuals readily distinguish *C. fragilis* from any known species of the genus.

CORYTHOCRINUS GRACILIS Kirk, n. sp.
Plate 40, figure 4

There is a single specimen representing this species. The specimen consists of an essentially complete crown with about 17 mm. of column attached.

The crown is compact in habit, with an over-all height of about 60 mm. The cup has a height of 7 mm., and an estimated diameter of 8 mm. at the arm bases. The cup is narrowly conical in form, and the surface of the plates is papillose.

The infrabasals are relatively low, having a height approximately one-third that of the cup. The height and the breadth of the infrabasals are about equal. The basals are relatively small, larger than the infrabasals, and of about equal height and breadth. The radials are relatively large. Their breadth is

about twice their height. The anal plate is of about the same width as the radials and considerably higher, extending well above the level of the radials. The anal plate rests unequally on the posterior and right posterior basals.

The arms are relatively more slender than in other species of the genus and have a height more than eight times the height of the dorsal cup. The surface of the brachials is papillose. The primibrachs are three in number and are high and relatively narrow. There seems to be but one division of the arms above the primaxil. This is high up, at more than one-half the height of the arms. There are numerous syzygial pairs of brachials. The pinnules are proportionally long and stout.

The column is circular in section, with a diameter of 2.3 mm. in its proximal portion.

Horizon and locality.—Upper part of Borden group (Mississippian), Crawfordsville, Indiana.

Type.—The holotype is in the Springer collection in the United States National Museum, S. 4440.

Remarks.—In general appearance this species most nearly resembles *C. insculptus*. The lack of pits at the angles of the plates of the dorsal cup and the great height at which the second bifurcations of the arms take place readily distinguish the species, however.

CORYTHOCRINUS INSCULPTUS Kirk, n. sp.
Plate 40, figures 2, 3

The species is represented by a single well-preserved crown, with a portion of the column attached. By removal from the matrix the specimen shows all the essential structures. In order to examine as much of the ventral sac as possible a portion of the arms of the right posterior radius was removed and replaced. In replacing the brachials, which had separated, it is probable that the original arrangement of the ossicles has not been reproduced exactly.

The crown, allowing for a few brachials that have been broken off, has a height of about 8.5 cm., of which the dorsal cup takes up but 1.25 cm. The arms are closely appressed and erect, giving the crown a subcylindrical aspect. The plates of the theca and the brachials are covered with granules. In the arms, especially above the first bifurcation, the granules tend to become confluent, forming irregular, somewhat wavy longitudinal lines.

The dorsal cup is flattened. In form it is subconical, with a diameter at the arm bases somewhat greater than the height. The plates of the dorsal cup are thin and fragile. They arch medially, the arching radiating outward and carrying across the sutures from plate to plate. At the angles the plates flex abruptly inward, forming pits. The arching of the plates gives them a fair amount of rigidity, so although fractured and somewhat displaced the plates are not greatly crushed.

The infrabasals form a prominent ring 3.6 mm. in height. The sutures show plainly. The basals are large, having an average height of about 5.5 mm. and an average maximum breadth of apparently about the same amount. In the type specimen the posterior basal is overthrust on the right posterior and the left anterior basal on the right anterior, owing to the crushing of the dorsal cup. The basals are hexagonal in outline except the right posterior, which is heptagonal, supporting the anal plate on its upper left shoulder. The posterior basal supports the anal plate on its upper right shoulder. The radials have an average maximum breadth of about 7.5 mm. and an average height of about 4.6 mm. They are pentagonal in outline except the right posterior radial, which is quadrangular. The straight articulating facet extends the full width of the radial, and the suture is gaping. There is a well-marked lunate ligament pit. The anal plate is relatively large, having a height of 6 mm. and a probable maximum breadth of about the same. The plate is crushed laterally, and it is difficult to get the exact width. Below, the anal plate rests on the posterior and right posterior basals. Laterally it lies in contact with the right and left posterior radials. Above it supports two tube plates. Only the lower dorsal portion of the ventral sac can be seen. Each of the proximal tube plates supports a vertical series of relatively heavy, strongly convex tube plates.

There are three primibrachs in each ray. The first primibrach, extending the full width of the radial, narrows rapidly distad, with concave lateral contours. The second primibrach is relatively small, while the third primibrach (primaxil) is considerably larger and widens rapidly distad. This gives the combined primibrachs a somewhat hourglass shape, with the maximum constriction on the level of the second primibrach. The secundibrachs vary in number from 16 to 20 in the half ray. The tertibrachs apparently number approximately the same as the secundibrachs, although in one series as shown the tertibrachs appear to be finials. In no case is there a bifurcation above the third axillary in this specimen. The development of syzygial pairs among the brachials is clearly shown. Except for the third brachial following the axillary and the brachial immediately preceding the axillary in each series except the primibrachs, all or practically all brachials form syzygial pairs. The possible exceptions are brachials that do not show clearly. At times the union of two brachials is so close as to amount practically to fusion, and one cannot at all times be certain as to whether one or two brachials are involved.

The column is large, with thicker walls than *C. fragilis*. The lumen appears to have been pentalobate, but of this one cannot be certain. The columnals are very low, there being approximately 18 columnals in a space of 5 mm. between 1.5 cm. and 2 cm. below the cup. The margins are crenulate. The proximal 5 mm. of the column appears to have columnals of quite different type from those distad. The condition was caused by a small spirally wrapped crinoid column which became deeply impressed into the larger column. Upon removal of the segment of small column the depressions made by it are shown.

Horizon and locality.—The type and only known specimen is from the upper part of the Borden group of Indian Creek, Montgomery County, Indiana.

Type.—The holotype is in the Springer collection in the United States National Museum, S. 4485.

Remarks.—The pits at the angles of the plates of the dorsal cup in this species readily distinguish it from any other known species of the genus.

CORYTHOCRINUS TENUIS Kirk, n. sp.
Plate 40, figure 8

There is a single specimen representing this species. The dorsal cup, part of the arms, and a small portion of the ventral sac are preserved. Attached to the crown is some 150 mm. of column. The specimen as found was partially embedded in dense crinoidal limestone, and the portion exposed was weathered. By undercutting, the dorsal cup was freed from the matrix, exposing the posterior side. The specimen does not show striking juvenile characteristics, and the individual may well be adult, or nearly so. The small size in any event is consonant with the early stratigraphic position of the form.

The crown is slender and compact in habit. The over-all height of the crown did not exceed 40 mm. The cup has a height of approximately 7.5 mm. and a diameter at the arm bases of approximately 5 mm. The cup is narrowly conical in form, and the surface of the plates appears to be smooth.

The infrabasals are long and narrow, having a height exceeding one-third that of the cup. The basals are likewise high and narrow and are larger than the infrabasals. The radials are relatively small, with a width greater than the height. The facet extends the full width of the radial. The anal plate is somewhat smaller than the radials and rests unequally on the posterior and right posterior basals, the shorter face making contact with the *r post B*.

The arms are relatively long and slender. There are three primibrachs. Compared with those of most of the later species the primibrachs of *C. tenuis* are high and narrow. The three primibrachs are of approximately equal height. The higher brachials are relatively high and narrow, with slightly sloping faces. So far as seen the rami do not bifurcate above the main division, and it is probable that they did not do so. It is not possible to tell accurately whether syzygial pairs of ossicles are present or not.

The column is comparatively stout. It is pentagonal in section in its proximal portion, becoming circular in section distad. The lumen is pentagonal.

Horizon and locality.—The holotype is from the upper part of the Burlington limestone ("Upper Burlington") at Burlington, Iowa.

Type.—The holotype is in the Springer collection in the United States National Museum, S. 4489.

Remarks.—The small size of the species, the pentagonal column in the proximal portion, the general proportions of the components of the crown, and the nonbifurcation of the arms above the main axil readily distinguish this species from other known forms.

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INTERVALLUM STRUCTURE OF CAMBROCYATHUS AMOURENSIS

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ONE of the most common species of Lower Cambrian pleosponges at Point Amour and Taylor's Gulch, Labrador, is *Cambrocyathus amourensis* Okulitch. In 1940 and 1941, I had the privilege of studying the abundant material collected by Dr. Dunbar from these localities. Among these specimens, no. 25643, Peabody Museum, Yale University, deserves special mention because of the remarkably fine preservation of minute details of the intervallum. A thin section, no. 67, made from the specimen, is preserved at the Royal Ontario Museum of Paleontology at Toronto.

The specimen consists of a *Cambrocyathus amourensis* surrounded by several concentric layers of *Exocyathus canadensis*. (See Pl. 41, fig. 1). This relationship is fairly common among the Labrador pleosponges. The central organism is 2.2 cm. in diameter and is clearly separated from the enveloping tissue by a fairly thick outer wall, pierced by distinct canallike pores. The inner wall is less distinct, as the central cavity is partly filled with trabecular tissue. This is the normal condition for the lower portions of the cups of Metacyathina, to which *Cambrocyathus* belongs. The intervallum contains fairly thick perforate radial parieties spaced about 1 mm. apart, and a complex of synapticulae and dissepiments, which can be called taeniae. The resultant mass of skeletal tissue assumes a vesicular appearance.

The most interesting feature of the specimen is that some of the vesicles of the intervallum are lined by a single layer of rounded rectangular cells. This is clearly shown on Plate 41, figure 2. Somewhat smaller cells line also the pores or short canals leading from one vesicle to another. The cells are variable in size, but of the order of magnitude of 0.02 cm. That is, their width is from one-tenth to one-fifth of the total diameter of each vesicle. Only a few of the vesicles have the cell lining. Since all vesicles are filled with crystalline calcite, it seems probable that the lack of cells in the majority of vesicles is due not to their original absence but to poor preservation. Each cell appears to be truly cellular and is separated from its neighbours by a thin line.

The appearance of the cells is such as could be expected of the cells of living tissue, which originally lined all the skeletal surfaces of the intervallum. As pointed out previously (Okulitch, 1943, p. 26), in the living organism the intervallum contained the bulk of the living tissue. This living tissue must have lined the skeletal elements, i.e. the outer and inner walls, the parieties, the canals, and in those families which had them, the synapticulae and the dissepiments. In this way, as in all other sponges, the circulating water passing through the pores and canals of the outer wall flowed past the living cells of the intervallum, and left the organism through the central cavity. This is the only method of feeding compatible with the skeletal arrangement of the pleosponges. It is quite likely that, since each individual cell had to provide its own nourishment, the living tissue was only one cell deep. From the foregoing it is highly suggestive that the cell-like structures observed lining the vesicles of the intervallum of *Cambrocyathus amourensis* represent the cells of the living tissue which lined in a similar manner the surfaces of the skeletal elements. Preservation of the outlines of soft living tissue in fossils is very rare, however it is not unknown. The body contours of some fossil fishes and the soft-bodied organisms of the Cambrian Burgess fauna are probably the best-known examples. Possibly after burial the decomposition of the living matter making up each cell resulted in selective precipitation of mineral matter, thus preserving the outline of each individual cell. If so, the specimen under discussion gives us a direct picture of the arrangement of living tissue within the intervallum of a pleosponge. This degree of preservation is exceedingly rare. So far I have seen it only in this particular specimen.

No other workers with pleosponges have mentioned it. It is therefore of especial interest that the same specimen shows the cell lining not only within the central organism, *Cambrocyathus amourensis*, but in portions of the problematical *Exocyathus canadensis*, which is attached to *Cambrocyathus* on the outside. There the cell lining is in every particular similar to the cell lining of *Cambrocyathus*. This is an additional indication of the essentially identical nature of the Exocyatha and the Archaeocyatha.

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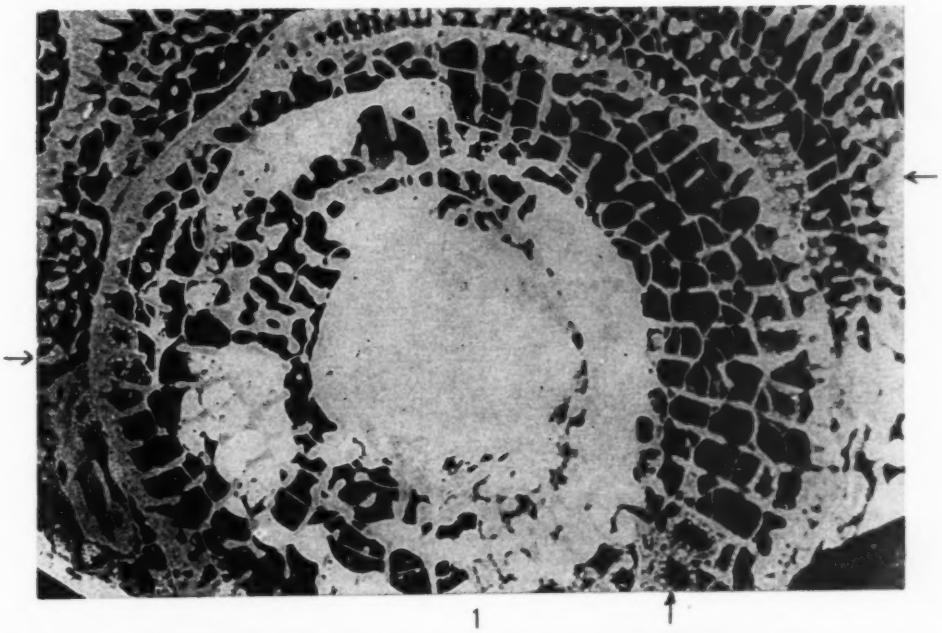
REFERENCE

OKULITCH, V. J., 1943, North American Pleospongia: Geol. Soc. America Special Papers 48.

EXPLANATION OF PLATE 41

FIGS. *1–2*—*Cambrocyathus amourensis* Okulitch. *1*, Royal Ontario Mus. slide 67, of Peabody Mus. 25643, ×5. Point Amour, Labrador. Transverse thin section showing the general appearance of the specimen, attached *Exocyathus* tissue, and cellular lining of some of the vesicles in the intervallum. Arrows point to the vesicles having the cellular lining. *2*, Portion of the intervallum, ×24. The single row of cells lining the walls of vesicles made by complex parieties and taeniae is clearly visible. In some places similar lining exists in the canals or passages linking adjacent vesicles. The heavier dark elements are perforated parieties, the thin curved lines are taeniae. The inside of the vesicles is mostly filled by crystalline calcite.

(p. 475)



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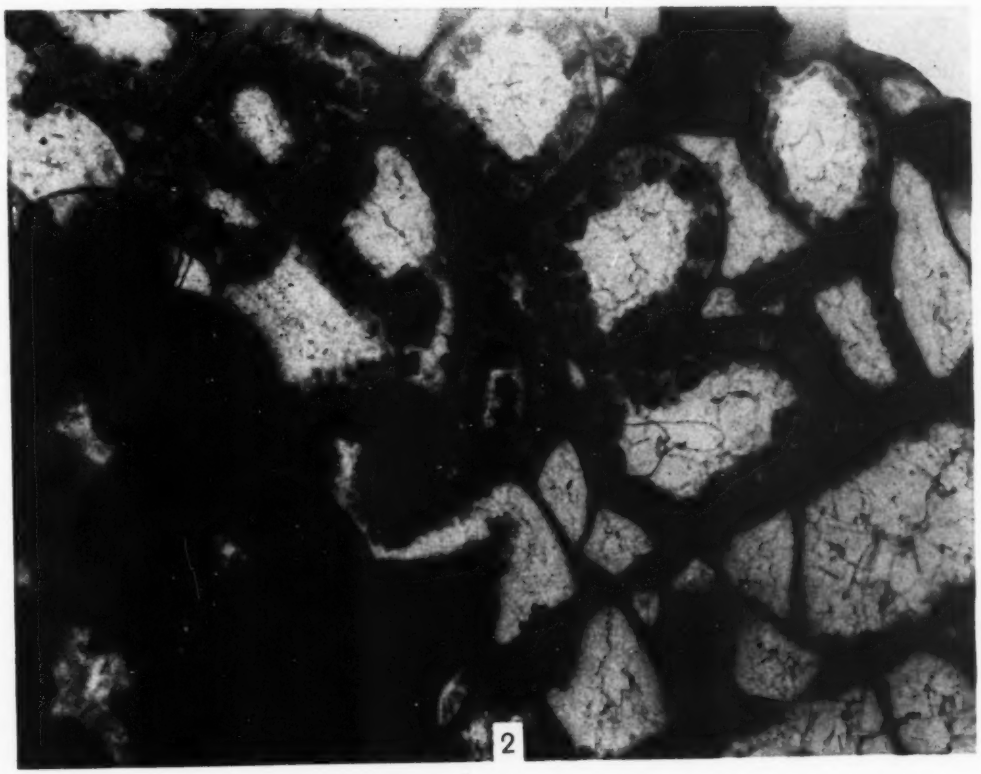

2

Cambrocyathus amourensis Okulitch

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Holmes, Walter W. Died Nov. 13, 1938.
*Hudson, George H. Died Mar. 19, 1934.
*Hyde, Jesse E. Died July 3, 1936.
Johnston, C. Stuart. Died July 23, 1939.
Kelly, Howard A. Died Jan. 12, 1943.
Keyte, I. A. Died May 29, 1931.
*Kindle, Edward M. Died Aug. 29, 1940.
*Knowlton, Frank H. Died Nov. 21, 1926.
*Lambe, L. M. Died Mar. 12, 1919.
*Lee, Willis T. Died June 17, 1926.
*Loomis, Frederick B. Died July 28, 1937.
Lusk, Ralph G. Died July 27, 1927.
Luther, D. D. Died Dec. 17, 1923.
Lyon, Victor W. Died Aug. 17, 1919.
MacBride, Thomas H. Died Mar. 27, 1934.
*Mansfield, Wendell C. Died July 24, 1939.
Martin, Bruce. Died Dec. 23, 1919.
Martin, Handell T. Died Jan. 15, 1931.
Matthew, Geo. F. Died Apr. 17, 1923.
*Matthew, W. D. Died Sept. 24, 1930.
Meachem, R. P. Died Feb. 13, 1934.
*Merriam, John C. Died Oct. 30, 1945.
Mesler, Rector D. Died Feb. 25, 1944.
Moody, W. L. Died Oct. 9, 1920.
Noble, C. Kingsley, Died Dec. 9, 1940.
*Noé, Adolf C. Died Apr. 10, 1939.
Nomland, Jorgen O. Died May 7, 1943.
*Parks, Wm. A. Died Oct. 3, 1936.
Patten, Wm. Died Oct. 23, 1932.
*Penhallow, David P. Died Oct. 20, 1910.
Peterson, O. A. Died Nov. 13, 1933.
*Prosser, C. S. Died Sept. 11, 1916.
*Rathbun, Mary Jane. Died Apr. 4, 1943.
*Resser, Charles E. Died Sept. 18, 1943.
Roundy, Paul V. Died June 21, 1937.
*Schuchert, Charles. Died Nov. 20, 1942.
*Seely, Henry M. Died May 4, 1917.
*Sinclair, W. J. Died Mar. 25, 1935.
Slocum, Arthur W. Died Nov. 20, 1937.
*Springer, Frank. Died Sept. 22, 1927.
Tegland, Nellie M. Died Dec. 1930.
Teller, Edgar E. Died July 19, 1923.
*Thomas, A. O. Died Jan. 13, 1931.
Tieje, Arthur J. Died Jan. 25, 1944.
*Tilton, J. L. Died Nov. 17, 1930.
Twitchell, G. B. Died Apr. 28, 1933.
*Twitchell, M. W. Died Apr. 8, 1927.
*Ulrich, Edward O. Died Feb. 23, 1944.
*Van Ingen, Gilbert. Died July 7, 1925.
*Vodges, Anthony W. Died Feb. 8, 1923.
*Walcott, Charles D. Died Feb. 9, 1927.
Waring, Charles A. Died Nov. 5, 1918.
Warner, William C. Died Sept. 29, 1941.
Weinzierl, Mrs. J. F. Died Sept. 28, 1928.
*Weller, Stuart. Died Aug. 5, 1927.
*White, David. Died Feb. 7, 1935.
*Whitfield, R. P. Died Apr. 6, 1910.
*Williams, Henry S. Died July 31, 1918.
*Williston, S. W. Died Aug. 30, 1918.
Wilson, Herrick E. Died Jan. 24, 1925.
Whittaker, Edw. Died Sept. 14, 1924.

NOMINATIONS FOR OFFICES IN THE PALEONTOLOGICAL SOCIETY FOR 1947

In accordance with the provisions of Chapter IV, Section 1, of the By-Laws, the Council of The Paleontological Society announces the following nominations for offices in the Society for 1947:

For President, R. C. Moore, Lawrence, Kan.
For Vice-President, G. Arthur Cooper, Washington, D. C.
For Secretary, H. E. Vokes, Baltimore, Md..
For Treasurer, Frank M. Swartz, State College, Pa.
For Editor, A. S. Warthin, Jr., Poughkeepsie, N. Y.

CHANGES OF ADDRESS

Members of The Paleontological Society are urged to notify the Secretary or the Treasurer of changes of address. Neglect to do so may cause bills to miscarry and result in the cancellation of the member's subscription to the Journal.

JOINT COMMITTEE ON ZOOLOGICAL NOMENCLATURE FOR PALEONTOLOGY IN AMERICA

ORGANIZATION

At the meeting of the Council of the Paleontological Society in December, 1943, attention was given to recent news of the renaissance of the International Commission on Zoological Nomenclature under the leadership of its new Secretary, Captain Francis Hemming of London. During the years of its inactivity shortly before and during the war, the danger of disintegration of all efforts for truly international cooperation had reached an alarming state, and the Council therefore set up a committee to investigate the situation and to report back to the Council of the Society at its next meeting. The Committee consisted of Prof. Carl O. Dunbar of Yale, Chairman, Prof. Alfred S. Romer of Harvard, and Dr. J. Brookes Knight then of Princeton and now of the Smithsonian Institution.

The Committee reported to the Council at the meeting in December 1944 that in its opinion the International Commission was fully alive and gave evidence of renewed activity far more effective than that of the past. It recommended that the Council approve the publication of an article in the Journal of Paleontology giving a brief resume of the history of the Commission, calling to the attention of American paleontologists the recent activities of the Commission, and urging on American paleontologists the need for the study and application of the Rules of Zoological Nomenclature. The Committee further recommended that the Society support the campaign of the International Commission for a revolving fund to finance its renewed activities. All of these recommendations were approved by the Council of the Paleontological Society at its meeting in December 1944, and steps were taken to effectuate the action proposed.

The Council of the Society reappointed the same Committee to continue for another year with instructions to consider further possibilities of advancing the cause of uniformity in nomenclature. Professor Dunbar felt constrained to refuse the chairmanship for the second year because of the pressure of other duties and Dr. Knight was made chairman in his place, although Professor Dunbar consented to remain a member of the Committee for the year.

The Committee met in New York on March 10th, 1945, and as a result of some preliminary discussions in the previous year and some correspondence with the Secretary of the International Commission concluded that a permanent committee should be formed to advance the interests of stability and uniformity in international zoological nomenclature insofar as American paleontology is concerned. It was thought that the proposed permanent committee should not be a committee of the Paleontological Society alone but that it should be sponsored by the three societies of paleontologists in North America, the Paleontological Society, the Society of Economic Paleontologists and Mineralogists, and the Society of Vertebrate Paleontology. The Committee unanimously agreed to submit to the officers of the three societies of Paleontologists for their official approval a plan whereby each of the societies would appoint a member of a Policy Board of three, the Policy Board to be, in effect, the executive committee of the enlarged permanent Joint Committee on Zoological Nomenclature for Paleontology in America. The ultimate control of the policies of the Committee would thus remain in the hands of the three societies by virtue of their power to appoint the members of the Policy Board. It was proposed that the other members of the Committee be selected by the Policy Board from qualified paleontologists, giving consideration to fields of specialization and to geographical and vocational representation. It was further proposed that the organization and function of the Committee be explicitly stated in a set of by-laws.

The original draft of the proposed by-laws submitted to the secretaries of the three societies and by them to the responsible officers of the societies were the subject of considerable discussion by correspondence and various amendments were suggested. Finally there emerged a draft that met the approval of the original Committee of the

Paleontological Society and of the responsible officers of the three societies. The by-laws are given below in full. The three members of the Paleontological Society's Committee were also confirmed as the directors of the initial Policy Board of the Joint Committee, each as the representative of one of the three societies as had been suggested. Invitations were then issued to nine other paleontologists to become members of the Joint Committee. The invitations were all accepted, thus completing the membership. These arrangements have now been confirmed by each of the three societies, and the Joint Committee is prepared to begin its operations in support of stability in zoological nomenclature on the foundation-stone of the International Code.

BY-LAWS

1. The name of the organization is Joint Committee on Zoological Nomenclature for Paleontology in America; hereinafter called the Committee.
2. The purpose of the Committee is to promote stability and uniformity in zoological nomenclature under the International Rules of Zoological Nomenclature (a) by encouraging the fullest understanding and use of the official publications of the International Commission on Zoological Nomenclature, (b) by informally aiding and advising American Paleontologists on matters of zoological nomenclature when requested to do so, and (c) by cooperating, on behalf of American Paleontologists, with the International Commission on Zoological Nomenclature.
3. It is expressly understood that the Committee has no power or desire to establish a code of nomenclature or to issue official interpretations of any code; nor does it prevent American Paleontologists who wish to deal directly with the International Commission on Zoological Nomenclature from doing so.
4. The Committee shall consist of not less than nine nor more than twelve members, three of whom, as directors, shall constitute the Policy Board of the Committee. The Paleontological Society, The Society of Vertebrate Paleontology, and The Society of Economic Paleontologists and Mineralogists shall each appoint one of the directors. The directors shall serve for three years, the term of office beginning January first, and one director shall be appointed each year. (For the purpose of establishing rotation, one of the first three directors shall serve one year, one two years and one three years, the terminal fraction of the first year served to count as a full year.)
5. The Policy Board shall determine all matters of policy, organization, and procedure, and shall be in charge of the finances of the Committee. It shall choose the chairman of the Committee, who shall also be chairman of the Policy Board, from its own membership.
6. The members of the Committee, other than the directors, shall be selected by the Policy Board solely on the basis of suitability to their functions. Each member shall serve three years. New members shall be selected to replace those whose terms have expired or who have resigned, in such manner as to provide rotation.
7. The Policy Board shall make a report of the activities of the Committee for the preceding twelve months by December 15th of each year to the secretaries of The Paleontological Society, The Society of Vertebrate Paleontology, and The Society of Economic Paleontologists and Mineralogists, respectively, and its records and files shall at all times be open for inspection to representatives of those societies.
8. The Paleontological Society, The Society of Vertebrate Paleontology and The Society of Economic Paleontologists and Mineralogists separately, shall be empowered to recall at any time the director whom they have appointed, but the Committee shall continue to function so long as two of the societies retain their directors in office.
9. These by-laws may be amended by the Policy Board, subject to the approval of each of the societies appointing a director to the Policy Board.

OBJECTIVES

The Committee feels that its objectives rank in importance in the order in which they are set down in article 2 of the by-laws, that its educational function is of first importance. To that end it urges and intends to continue to urge that the techniques of zoological nomenclature and the philosophies on which these are based be given far more attention in the training of young paleontologists than has been done in the past at many important institutions. Furthermore it urges that working paleontologists in all fields and particularly in taxonomic work acquaint themselves with and apply the Rules of Zoological Nomenclature as an essential tool of their trade, the neglect of which leads to lack of precision and to unnecessary semantic confusion. This is not always easy owing to the inherent difficulties in so complex a matter, and to occasional ambiguities in the Rules themselves. This brings us to the second objective of the Committee, to aid and advise American paleontologists informally on matters of zoological nomenclature.

The Committee has no powers to issue formal opinions or to legislate on nomenclatural matters. All such powers reside in the International Commission. Nevertheless, the personnel of the Committee is composed of specialists in various fields and representatives of various vocational points of view, all of whom are interested in uniformity in nomenclature under the International Rules. The Committee therefore offers its services in interpreting the Rules where simple problems are involved and in advising on matters to be brought before the International Commission where they are more complex or controversial. Other ways that the Committee may be of service will readily come to mind.

American paleontologists of whatever field of specialization or vocational interest are urged to remember that this is their committee. Its success will depend to a large degree on how extensively American paleontologists make use of it. The Committee must not be regarded as a lower court that stands as a barrier between the International Commission and any paleontologist who wishes to approach it, but rather as an organized group of consultants ready to serve where its services are requested.

PROCEDURE

The Policy Board of the Committee has adopted the following resolution on procedure:

All communications to the Committee or requests for advice or aid on nomenclatural matters should be addressed to the chairman. Depending on the nature of the matter communicated, the chairman may handle it himself or may call upon any or all members of the Committee for assistance. He shall send copies of all communications with paleontologists to the other two members of the Policy Board. (To facilitate this, paleontologists are urged to enclose two carbon copies with their communications.) Paleontologists requesting advice or aid on some nomenclatural problem or support for some program are urged to state the problem or program clearly and concisely with full bibliographical references to all relevant published material.

It is intended that the advice tendered by the Committee will be expert but that it will be unofficial. If the solution to a problem is not evident or if important differences of interpretation arise between members of the Committee or between a paleontologist and the Committee, the Committee stands ready to present the matter to the International Commission, with or without recommendation, for official action.

MEMBERSHIP

The membership of the Joint Committee for 1946 is given below. Professor Carl O. Dunbar of Yale University was the representative of The Paleontological Society on the initial Policy Board for the term expiring December 31, 1945.

Policy Board

ALFRED S. ROMER (term expires Dec. 31, 1946) for The Society of Vertebrate Paleontology.

J. BROOKES KNIGHT, *Chairman* (term expires Dec. 31, 1947) for The Society of Economic Paleontologists and Mineralogists. Address: U. S. National Museum, Washington 25, D. C.

JOHN B. REESIDE, JR. (term expires Dec. 31, 1948) for The Paleontological Society.

Other Members

A. MYRA KEEN	1946
HELEN JEANNE PLUMMER	
GAYLE SCOTT	1946–1947
RAYMOND C. MOORE	
H. B. STENZEL	
JOHN W. WELLS	
G. ARTHUR COOPER	1946–1948
NORMAN D. NEWELL	
GEORGE GAYLORD SIMPSON	

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NOMENCLATURAL NOTES

PUBLICATIONS OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

In furtherance of its purpose to promote uniformity in the nomenclature of fossil animals the Joint Committee on Zoological Nomenclature for Paleontology in America proposes to submit from time to time for publication in the Journal of Paleontology items of nomenclatural interest. These items may well include matters of general interest before the Committee or on which the Committee seeks the advice and counsel of Paleontologists. It seems important also that Paleontologists be kept informed of current publications of the International Commission on Zoological Nomenclature.

Although most of the *Opinions* issued by the Commission during the secretaryship of the late Dr. Charles W. Stiles (*Opinions* 1–133) were decisions on special cases brought before the Commission, many of them established important general principles, which the student had to seek out for himself. Under the leadership of Secretary Hemming, however, the Commission issues a separate *Opinion* for each general principle established in deciding special cases. Consequently, although every general library should have on its shelves a complete set of the publications of the Commission, many of the *Opinions* currently issued have little significance for anyone except those specialists concerned with the name or names mentioned in the title or summary. Those *Opinions* that appear to the Secretary of the Committee to deal with general principles have been marked by an asterisk in the appended list, which includes all publications issued, in press, or proposed as of March 1, 1946.

These publications are for sale by the *Publications Office, International Commission on Zoological Nomenclature, 41 Queen's Gate, London S.W. 7, England.* Remittances should be made to the order of *International Commission on Zoological Nomenclature, Coutts & Co.*, and should be in pounds sterling, payable in London.

OPINIONS AND DECLARATIONS RENDERED BY THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

These *Opinions* and *Declarations* are being published in three volumes concurrently, each including numerous parts, priced separately. Volume 1 will contain nine Declarations never previously published and a reissue of Opinions 1–133, the original edition of which is now exhausted. Volume 2 will contain Declarations 10–12 and Opinions 134–181, all of which were adopted by the International Commission at their meeting in Lisbon in 1935. Volume 3 will contain Opinions adopted by the Commission since their Lisbon meeting. The titles of the parts so far issued or now in press are:

Volume 1 (1943–)

**Part 1, Declaration 1.*—Code of ethics to be observed in the renaming of homonyms. Price 1s. 6d.

**Part 2, Declaration 2.*—On the importance of avoiding the issue of authors' reprints or separata in advance of the publication of the work or journal in which the paper in question is to be published. Price 1s. 6d.

**Part 3, Declaration 3.*—On the importance of giving a clear indication of the date of issue of every zoological publication. Price 1s. 6d.

**Part 4, Declaration 4.*—On the need for avoiding intemperate language in discussion on zoological nomenclature. Price 1s. 6d.

**Part 5.—Declaration 5.*—On the grant to the International Commission on Zoological Nomenclature of plenary powers to suspend the rules in certain cases. Price 2s. 6d.

**Part 6, Declaration 6.*—On the need for new names to be clearly indicated as such on their first publication and on the need for avoiding the publication of names as new on more than one occasion. Price 1s. 6d.

**Part 7. Declaration 7.*—On the need for quoting bibliographical or other references for all names cited in zoological works. Price 1s. 6d.

**Part 8, Declaration 8.*—On the need for giving in the case of zoological journals a clear indication of the date of publication of each number or part. Price 1s. 6d.

**Part 9, Declaration 9.*—On the desirability of universities including zoological nomenclature in their courses of general and systematic zoology. Price 1s. 6d.

**Part 10, Opinion 1.*—The meaning of the word "indication" in proviso (a) to Article 25 of the International Code, as respects names published on, or before, 31st December 1930. Price 4s.

**Part 11, Opinion 2.*—The nature of a systematic name. Price 1s. 6d.

**Part 12, Opinion 3.*—The status of publications dated 1758. Price 1s. 6d.

**Part 13, Opinion 4.*—The status of names published as manuscript names. Price 3s.

**Part 14, Opinion 5.*—The status of certain pre-Linnean names reprinted subsequent to 1757. Price 3s.

**Part 15, Opinion 6.*—On the type of a genus "*A*———," containing two species, "*A*——— *b*———" and "*A*——— *c*———" where the generic name in question was published on, or before, 31st. December 1930. Price 3s.

**Part 16, Opinion 7.*—On the interpretation of the expression "n.g., n.sp." under Article 30(a) of the International Code, as respects generic names published on, or before, 31st December 1930. Price 1s. 6d.

**Part 17, Opinion 8.*—On the retention of "*ii*" or "*i*" in specific patronymic names, under Article 14, third paragraph, and Article 19 of the International Code. Price 3s.

**Part 18, Opinion 9.*—The use of the name of a composite genus for a component part requiring a name, where the name so used was published on, or before, 31st December 1930. Price 3s.

**Part 19, Opinion 10.*—The designation of genotypes for genera published with identical limits, on, or before, 31st December 1930. Price 1s. 6d.

**Part 20, Opinion 11.*—The designation of genotypes by Latreille, 1810, *Consid. gén. Crust. Arach. Ins.* (with a facsimile). Price 3s.

**Part 21, Opinion 12.—Stephanoceros fimbriatus* (Goldfuss, 1820) versus *Stephanoceros eichhornii* Ehrenberg [1832] (class Rotifera, order Flosculariacea). Price 3s.

Part 22, Opinion 13.—The specific name of the sand crab (2 plates). In press.

Part 23, Opinion 14.—The type species of *Etheostoma* Rafinesque, 1819 (class Pisces, order Percnomorphi). In press.

Part 24, Opinion 15.—Craspedacusta sowerbii Lankaster, 1880, n. g., n. sp. versus *Limnocodium victoria* Allman, 1880, n.g., n. sp., a freshwater medusa (class Hydrozoa, order Trachymedusae). In press.

Part 25, Opinion 16.—The status, under rule (d) in Article 30, of pre-binomial specific names (published prior to 1758) in relation to a generic name published on, or before, 31st December 1930. In Press.

Part 26, Opinion 17.—Shall the generic names of Weber (F.), 1795, *Nomenclator entomologicus Fabricii*, be accepted? (4 facsimiles). In press.

Part 27, Opinion 18.—The type of *Hydrus* Schneider, 1799 (class Reptilia, order Squamata) (interpretation of rule (d) in Article 30 of the *Règles Internationales*). In press.

Part 28, Opinion 19.—Plesiops Oken, 1817, versus *Pharopteryx* Rüppell, 1828 (class Pisces, order Percnomorphi). In Press.

Part 29, Opinion 20.—Shall the generic names of Gronovius, 1763, *Zoophylacium Gronovianum*, be accepted? (meaning of the expression "nomenclature binaire" (binary nomenclature) as used in the *Règles Internationales*). In press.

Volume 2 (1939–)

This volume is being published in two sections (Sections A and B) with continuous pagination. Section A is now complete in 31 parts (parts 1–30, 30A), price four guineas (£4. 4s. 0d.). Fifteen parts (parts 31–45) cf. Section B have been published and the remainder are in press.

Section A (1939–1945)

Part 1, Opinion 134.—On the method to be adopted in interpreting the generic names assigned by Freyer to species described in his *Neuere Beiträge zur Schmetterlingskunde*, 1833–1858. Price 8d.

Part 2, Opinion 135.—The suppression of the so-called "Erlangen List" of 1801. Price 8d.

Part 3, Opinion 136.—Opinion supplementary to Opinion 11 on the interpretation of Latreille's *Considérations générales sur l'ordre naturel des animaux composant les classes des Crustacés, des Arachnides et des Insectes avec un tableau méthodique de leurs genres disposés en familles*, Paris, 1810. Price 1s.

Part 4, Opinion 137.—On the relative precedence to be accorded to certain generic names published in 1807 by Fabricius and Hübner respectively for identical genera in the Lepidoptera Rhopalocera. Price 1s. 6d.

**Part 5, Opinion 138.*—On the method by which the amendment to article 25 of the International Code adopted at the Budapest meeting of the International Zoological Congress, relating to the replacement of invalid names, should be interpreted. Price 1s. 6d.

Part 6, Opinion 139.—The names *Cephus* Latreille [1802–1803] and *Astata* Latreille, 1796, in the Hymenoptera added to the Official List of Generic Names. Price 2s 6d.

Part 7, Opinion 140.—On the method of forming the family names for *Merops* Linnaeus, 1758 (Aves) and for *Merope* Newman, 1838 (Insecta). Price 2s.

**Part 8, Opinion 141.*—On the principles to be observed in interpreting Article 4 of the International Code relating to the naming of families and subfamilies. Price 2s. 6d.

Part 9, Opinion 142.—Suspension of the rules for *Satyrus* Latreille, 1810 (Insecta, Lepidoptera). Price 2s. 6d.

Part 10, Opinion 143.—On the method of forming the family name for *Tingis* Fabricius, 1803 (Insecta, Hemiptera). Price 2s. 6d.

Part 11, Opinion 144.—On the status of the names *Crabro* Geoffroy, 1762, *Crabro* Fabricius, 1775, and *Cimbex* Olivier, 1790 (Insecta, Hymenoptera). Price 2s. 6d.

**Part 12, Opinion 145.*—On the status of names first published in works rejected for nomenclatorial purposes and subsequently published in other works. Price 2s. 6d.

Part 13, Opinion 146.—Suspension of the rules for *Colias* Fabricius, 1807 (Insecta, Lepidoptera). price 2s. 6d.

**Part 14. Opinion 147.*—On the principles to be observed in interpreting Article 34 of the International Code in relation to the rejection, as homonyms, of generic and subgeneric names of the same origin and meaning as names previously published. Price 2s. 6d.

**Part 15, Opinion 148.*—On the principles to be observed in interpreting Articles 25 and 34 of the International Code in relation to the availability of generic names proposed as emendations of, or as substitutes for, earlier generic names of the same origin and meaning. Price 2s. 6d.

Part 16, Opinion 149.—Twenty-one names in the Orthoptera (Insecta) added to the *Official List of Generic Names in Zoology*. Price 4s.

Part 17, Opinion 150.—On the dates of pub-

lication of the several portions of Hübner (J.), *Verzeichniss bekannter Schmettlinge* [sic], 1816–[1826]. Price 2s. 6d.

**Part 18, Declaration 10.*—On the importance of forming specialist groups for the study of the nomenclature of particular divisions of the Animal Kingdom. Price 1s. 6d.

**Part 19, Declaratibn 11.*—On the need for a clear indication in the description of new genera and species of the order and family involved. Price 1s. 6d.

Part 20, Opinion 151.—On the status of the names *Lasius* Panzer [1801–1802], *Podalirius* Latreille, 1802, *Lasius* Fabricius [1804–1805], and *Anthophora* Latreille, 1803 (class Insecta, order Hymenoptera). Price 3s.

Part 21, Opinion 152.—On the status of the generic names in the order Diptera (class Insecta) first published in 1800 by J. W. Meigen in his *Nouvelle Classification des Mouches à deux ailes*. Price 4s.

**Part 22, Declaration 12.*—On the question of breaches of the Code of Ethics (*Declaration* supplementary to *Declaration 1*). Price 1s. 6d.

Part 23, Opinion 153.—On the status of the names *Bethylus* Latreille [1802–1803], and *Dryinus* Latreille [1804] (class Insecta, order Hymenoptera). Price 3s.

Part 24, Opinion 154.—On the status of the names *Phaenrotpera* Serville, 1831 and *Tylopsis* Fieber, 1853 (class Insecta, order Orthoptera). Price 5s.

Part 25, Opinion 155.—On the status of the names *Callimome* Spinola, 1811, *Misocampe* Latreille, 1818, and *Torymus* Dalman, 1820 (class Insecta, order Hymenoptera). Price 3s.

Part 26, Opinion 156.—Suspension of the rules for *Vanessa* Fabricius, 1807 (class Insecta, order Lepidoptera). Price 3s.

Part 27, Opinion 157.—Three names in the order Hymenoptera (class Insecta) added to the *Official List of Generic Names in Zoology*. Price 3s.

Part 28, Opinion 158.—On the status of the name *Locusta* Linnaeus, 1758 (class Insecta, order Orthoptera). Price 3s.

Part 29, Opinion 159.—On the status of the names *Ephialtes* Schrank, 1802, *Ichneumon* Linnaeus, 1758, *Pimpla* Fabricius [1804–1805], and *Emphialtes* Gravenhorst, 1829 (class Insecta, order Hymenoptera). Price 4s.

**Part 30, Opinion 160.*—On the status of the name *Anguina* Scopoli, 1777, *Anguillulina* Gervais and van Beneden, 1859, and *Tylenchus* Bastian, 1865 (class Nematoda. Price 4s.

**Part 30A*, Title-page, indexes, etc., to Section A. (Includes supplementary note on Opinions 137, 148, and 149). Price 8s. 2d.

Section B (1945–)

Part 31, Opinion 161.—Suspension of the rules of *Argynnis* Fabricius, 1807 (class Insecta, order Lepidoptera). Price 3s.

Part 32, Opinion 162.—Suspension of the rules for *Bracon* Fabricius [1804–1805] (class Insecta, order Hymenoptera). Price 4s.

Part 33, Opinion 163.—Suspension of the rules for *Euploea* Fabricius, 1807 (class Insecta, order Lepidoptera). Price 3s.

**Part 34, Opinion 164.*—On the principles to be observed in interpreting Article 30 of the International Code in relation to the types of genera when two or more genera are united on taxonomic grounds. Price 3s.

Part 35, Opinion 165.—Need for the suspension of the rules for *Strymon* Hübner, 1818 (class Insecta, order Lepidoptera) not established. Price 4s.

Part 36, Opinion 166.—On the status of the names *Pompilus* Fabricius, 1798, and *Psammochares* Latreille, 1796 (class Insecta, order Hymenoptera) and of the alleged generic name *Pompilus* Schneider, 1784 (class Cephalopoda, order Nautiloidea). Price 6s.

Part 37, Opinion 167.—Suspension of the rules for *Euthalia* Hübner [1819] (class Insecta, order Lepidoptera). Price 3s.

**Part 38, Opinion 168.*—On the status of genera based upon erroneously determined species (*Opinion* supplementary to *Opinion* 65). Price 5s.

Part 39, Opinion 169.—On the type of the genus *Lycaeides* Hübner [1819] (class Insecta, order Lepidoptera), a genus based upon an erroneously determined species. Price 3s.

Part 40, Opinion 170.—Need for the suspension of the rules for *Prosopis* Jurine, 1807 (class Insecta, order Hymenoptera) not at present established. Price 4s.

Part 41, Opinion 171.—Suspension of the rules for *Nymphidium* Fabricius, 1807 (class Insecta, order Lepidoptera). Price 3s.

**Part 42, Opinion 172.*—On the interpretation of Article 30 of the International Code in relation to the designation, in abstracts and similar publications, of the types of genera, the names of which were published on, or before, 31st December 1930. Price 3s.

Part 43, Opinion 173.—On the type of the genus *Agriades* Hübner [1819], and its synonym *Latiorina* Tutt, 1909 (class Insects, order Lepidoptera), genera based upon erroneously determined species. Price 3s.

Part 44, Opinion 174.—On the status of the names *Ceraphron* Panzer [1805], and *Ceraphron* Jurine, 1807 (class Insecta, order Hymenoptera). Price 3s.

Part 45, Opinion 175.—On the type of the genus *Polyommatus* Latreille, 1804 (class Insecta, order Lepidoptera). Price 3s.

Part 46, Opinion 176.—On the type of *Conulinus* von Martens, 1895 (class Gastropoda, order Stylommatophora) (*Opinion* supplementary to *Opinion 86*). In press.

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Kirby, 1798 (class Insecta, order Hymenoptera). In press.

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Part 52, Title-page, indexes, etc., to Section B. In press.

Volume 3 (1944–)

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Part 12, Opinion 193. On the status of the name *Procheneosaurus* Matthew, 1920 (class Reptilia, order Ornithischia). In press.

Part 13, Opinion 194. On the status of the name *Ophiceras* Griesbach, 1880 (class Cephalopoda, order Ammonoidea). In press.

Bulletin of Zoological Nomenclature

This journal was established by the International Commission on Zoological Nomenclature in 1943 to be their Official Organ, in order to provide a medium for the publication of:

(a) proposals on zoological nomenclature submitted to the International Commission for deliberation and decision;
(b) comments received from, and correspondence by the Secretary with, zoologists on proposals published in the *Bulletin* under (a) above; and
(c) papers on nomenclatorial implications of developments in taxonomic theory and practice.

Seven parts of volume 1 have so far been published and four further parts are in the press and will be published shortly. The prices of parts 1–7 are 9s., 5s., 30s., 6s., 8s., 6s., and 10s., respectively.

Règles Internationales de la Nomenclature Zoologique (International Code of Zoological Nomenclature)

The forthcoming edition of the above work will comprise the substantive French text (on left-hand pages) and the corresponding English translation (on right-hand pages). A brief historical account of the development of the *Règles Internationales* will also be included, together with an analysis of the *Opinions* rendered by the International Commission on Zoological Nomenclature, setting out the interpretations so given of various Articles of the *Règles*. The volume will conclude with a full subject index.

Prospective subscribers who register as such and who remit the purchase price prior to publication, will be charged 20 per cent less per copy than the price which will be payable on and after the date of publication.

The Official List of Generic Names in Zoology

The International Commission on Zoological Nomenclature attach great importance to the *Official List of Generic Names in Zoology* as a means for promting the stabilisation of zoological nomenclature and for this reason they are doing everything possible to expedite the issue of the forthcoming edition of this work. It will be in book-form and will contain full bibliographical references and other particulars relating to the generic names (nearly 700 in number) so far placed on the *Official List* and their type species. It is proposed to include in the same volume particulars relating to all other decisions taken by the International Commission in *Opinions* in regard to particular names. This work will, therefore, constitute a complete guide to all such decisions. Full indexes (both systematic and alphabetical) will be included.

As in the case of the *Règles Internationales*, a discount of 20 per cent will be granted in respect of pre-paid subscriptions received before the date of publication.

JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 3, PP. 295–296, MAY 1946

PALEONTOLOGICAL NOTES

VELATES VOKESI, NEW NAME FOR NERITINA? GRANDIS COOKE

C. WYTHE COOKE
Geological Survey, Washington, D. C.

VELATES VOKESI Cooke, n. name

Neretina? grandis, Cooke, 1919, Carnegie Inst. Washington Pub. 291, p. 126, pl. 5, figs. 7, 8. Not *Neritina grandis* Sowerby, 1840.
Velates grandis (Cooke) Vokes, 1935, California Univ. Dept. Geol. Sciences, Bull., vol. 23, no. 12, p. 383.

The original name of this species is a homonym even though the generic name was misspelled because of a typographical error. Its close relationship to *Velates* was pointed out in the original description.

The species occurs in the late Eocene St. Bartholomew limestone of the West Indies. The type is U. S. Nat. Mus. 167038.

BANCROFTINA, A NEW BRACHIOPOD NAME

G. WINSTON SINCLAIR
Sir George Williams College, Montreal

In the May 1945 issue of this Journal the late J. B. B. Bancroft[1] described a new genus of orthoid brachiopods under the name *Raymondella*, thereby intending to honor his brother. Unfortunately this name had been used by Reed[2] for a subgenus of the trilobite *Dionide*. It seems appropriate that this homonym be replaced by a name continuing not only the original compliment, but also the memory of its giver. I therefore propose the new name *Bancroftina*, to replace *Raymondella* Bancroft 1945 (not Reed 1935). The genotype is *Bancroftina typa* (Bancroft) 1945.

[1] BANCROFT, B. B., 1945, The brachiopod zonal indices of the stages Costonian to Onnian in Britain: Jour. Paleontology, vol. 19, pp. 197–198.

[2] REED, F. R. C., 1935, The lower Palaeozoic trilobites of Girvan, supplement 3: Palaeontographical Soc., vol. 88, fasc. 4, pp. 8–9.

HOWELLELLA, A NEW NAME FOR CRISPELLA KOZLOWSKI, 1929

ROMAN KOZLOWSKI
University of Warsaw

Professor B. F. Howell of Princeton University has been so kind as to call my attention to the fact that the generic denomination *Crispella* which I used in my publication of 1929 "Les brachiopodes gotlandiens de la Podolie polonaise" to distinguish the type of brachiopod of which the well-known Silurian species *Spirifer crispus* (Hisinger) is the genotype was preoccupied in 1870 by Gray. My name must therefore be replaced by a new one. I thank Professor Howell for this information and propose to substitute for the name *Crispella* the new name *Howellella*.

PERIPHERAL APERTURES IN MISCELLANEA

T. WAYLAND VAUGHAN
Washington, D. C.

Recently in discussing *Miscellanea miscella* and *M. stampi* I published the following statements (Vaughan, 1945, p. 24):

> Mr. D. W. Gravell in a letter to me has noted the presence of a large canal in the marginal cord of these species (see Vaughan and Cole, 1941, pl. 5, figs. 1, 3, 3a), but I am not convinced of the taxonomic significance of this feature. I have not taken time to go over large suites of Camerinidae to test it, but I have examined a few species. There is a large canal in the marginal cord of some species, at least of *Operculinoides ocalanus* (Cushman) (Vaughan and Cole, 1941, pl. 9, figs 3, 4), *O. tamanensis* Vaughan and Cole (1941), pl. 11, figs. 9, 10), *O. semmesi* Vaughan and Cole (1941, pl. 15, figs. 1, 2). and *O. semmesi* var. *ciperensis* Vaughan and Cole, 1941, pl. 15, fig. 3). The presence of what appears to be a large canal in the marginal cord of species of Camaerinidae is not rare. I should hesitate to use it as a generically diagnostic feature.

Lt. Col. L. M. Davies of Edinburgh in a letter to me dated December 16, 1945, takes issue with the interpretation of the large aperture just inside the peripheral wall in the axial section of *Miscellanea stampi* (Davies) (Vaughan and Cole. 1941, pl. 5, figs. 3, 3a) as a canal. In his opinion the aperture represents a section across the recurved tip of a chamber immediately distal to an earlier chamber in the same whorl. Figures 2 and 4 of plate 5 in Vaughan and Cole (1941) illustrate median sections of *Miscellanea miscella* and *M. stampi*. The successive chambers are strongly recurved peripherally. A section, therefore, may cut the distal tip of a younger chamber and the main body of the next older chamber in the same whorl and produce the appearance illustrated by figures 3 and 3a of plate 5 in the paper mentioned.

I am convinced that Colonel Davies is right, and I thank him for bringing this matter to my attention.

REFERENCES

VAUGHAN, T. W., 1945, Paleocene and Eocene larger Foraminifera from Barbados: Geol. Soc. America Mem. 9.

—— and COLE, W. S., 1941, Preliminary report on the Cretaceous and Tertiary larger Foraminifera of Trinidad, British West Indies: Geol. Soc. America Special Papers no. 30.

AN APPEAL

As Secretary of the International Paleontological Union, I have received a number of appeals from European paleontologists for assistance in replacing libraries, teaching collections, and equipment destroyed during the war. I shall be glad to cooperate with other American or Canadian paleontologists who may wish to send publications, fossils, or instruments to friends in Europe who are in need of them. I will forward any such contributions that are sent to me.

I wish to make a special appeal for such assistance for Professor Roman Kozlowski, of the University of Warsaw, and Professor Louis Dangeard, of the University of Caen. Professor Kozlowski's and Professor Dangeard's laboratories were completely destroyed with all their contents. These gentlemen will be very grateful for any assistance which their North American colleagues may extend to them.

In case members of the Paleontological Society or the Society of Economic Paleontologists and Mineralogists wish to send material directly to professors Kozlowski or Dangeard, rather than through me, I give their addresses here. Professor Kozlowski's address is: Zaklad Paleontologii, Universytet Warszawski, ul. Wilcza 22 m. 4, Warsaw, Poland. Professor Dangeard's address is: Laboratorie de Géologie et Paléontologie, Faculté des Sciences, Université de Caen, Caen, Calvados, France.

B. F. HOWELL

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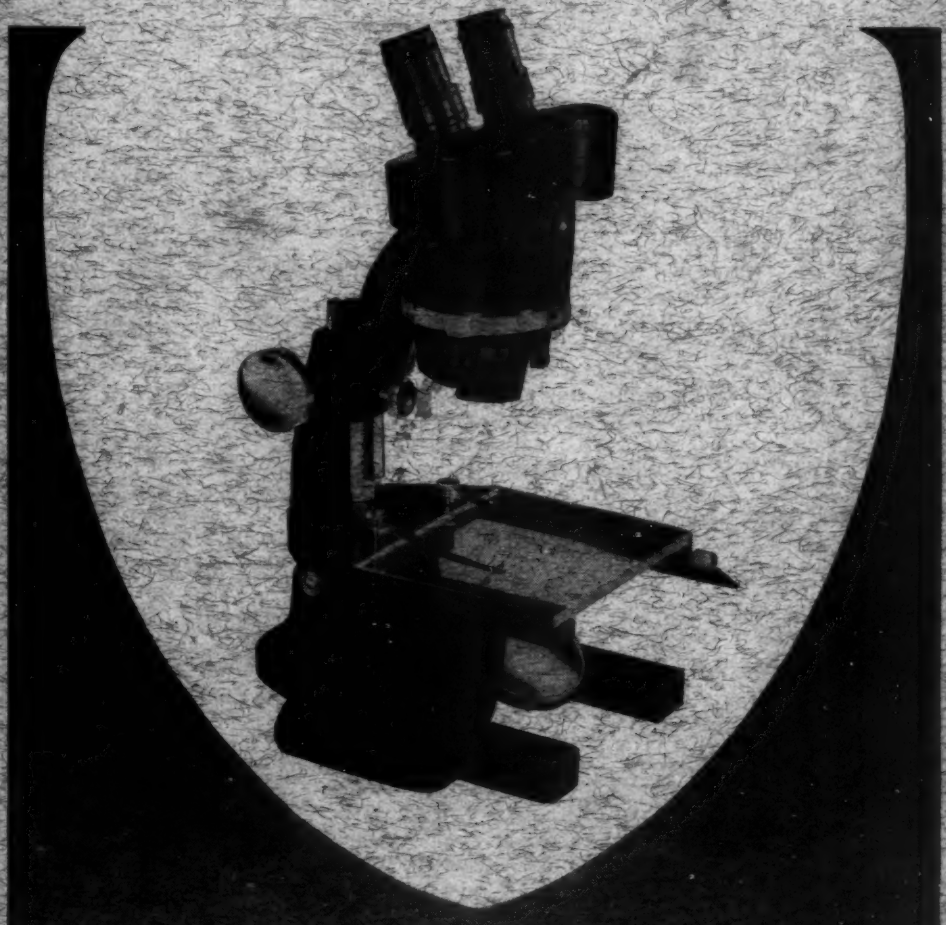

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